Citrix XenDesktop VDI

Capacity Testing Using Tintri VMstore™

Citrix Ready VDI Capacity Program Phase II

A performance test of the Tintri VMstore™ storage system, which supported a realistic Citrix XenDesktop workload leveraging Citrix Provisioning Services in a simulated 1,500-user environment

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The decision to virtualize desktops affects multiple aspects of an IT organization, including infrastructure and storage requirements, application delivery, end-user devices, and technical support. In addition, correctly architecting, deploying, and managing a virtual desktop infrastructure (VDI) can be challenging due to the large number of solution components contained within the architecture. Therefore, it is critical that the solution is built on industry-proven platforms such as Tintri VMstore, along with industry-proven software solutions from Citrix.

Citrix and Tintri provide leading desktop virtualization and storage solutions, respectively, that enable customers to successfully meet the challenges inherent with VDI. Customers can gain the numerous benefits available from a desktop virtualization solution, including workspace mobility, centralized management, consolidated and secure delivery of data, and device independence.

This white paper summarizes performance tests of the Tintri T5060 VMstore all-flash storage array and Tintri T850 VMstore version 4.0.1.9 — the middle model of three all-flash models available in Tintri's line of all-flash arrays (T5000) and Tintri's line of hybrid (T800). These tests (LoginVSI "knowledge worker x 2vCPU") simulated a 1,500-user load in a realistic Citrix XenDesktop Provisioning Services environment. This paper also discusses a range of benefits offered in all Tintri VMstores, including visibility, simplified management and ease-of-use.

Ultimately, both the Tintri T5060 all-flash and the Tintri T850 Hybrid-Flash VMstores are shown to work perfectly with Citrix XenDesktop in containing costs and maximizing the benefits of VDI.

The Promise and the Challenge of VDI

Virtual desktops have grown in popularity in recent years. As more companies have freed their workers from the figurative shackles of traditional desktops, VDI systems such as Citrix XenDesktop have grown as well.

The promise of VDI is clear. Virtualizing and centralizing desktops offers a more secure, more manageable, and less costly end-user computing model. Consequently, the increasing availability of scalable server architecture has made virtual desktops more than just technically feasible.

Present Need for Solution

In spite of the massive potential that VDI offers in transforming the modern workplace, adoption has been slow. The most significant barriers to increased adoption of VDI are rooted in storage performance shortfalls, capacity problems and soaring VDI infrastructure costs.

Common barriers to realizing the full potential of VDI include:

- **Latency:** The latency spikes that are common with traditional storage systems regularly induce performance lags. The performance shortfalls, in turn, inhibit user acceptance and diminish productivity.

- **Lack of Visibility:** The jumble of LUNs, volumes, RAID groups, and other cogs of traditional storage systems render it virtually impossible to have a clear and continuous overview of system functionality. Problem outliers and one-off performance issues that degrade system reliability and usability can remain hidden behind a veil of complexity.

- **Management Complexity:** Most VDI administrators are not storage experts. Yet traditional storage systems are extremely complex, requiring expert-level knowledge just to troubleshoot common problems. That complexity can hinder the rapid troubleshooting that is sometimes essential to properly managing VDI.

- **High Costs:** VDI deployments are frequently initiated with the primary goal of reducing equipment and management costs. But the anticipated ROI of VDI deployments frequently fail to materialize. High storage costs are commonly to blame. In fact, storage often is found to represent the single most expensive component of a virtual desktop solution — particularly when storage efficiency falls short and the capabilities of flash acceleration technologies are not used.

Top Features to Consider in a Modern VDI Storage Solution

Exercising careful consideration in the selection of a VDI storage solution can eliminate these barriers noted above. It is the key to fully realizing the promise and potential of a VDI installation.

In particular, the following features are conducive to maximizing the potential of VDI:

1. **Ease of Administration:** Storage for virtual machines (VMs) should be managed — and should be manageable — at the VM level. This should include common VDI managerial responsibilities such as monitoring, replicating, cloning, taking snapshots, and analyzing individual VMs.

2. **Manageability:** Users should not require manual intervention, and should not be forced to rely upon sprawling spreadsheets. All basic storage tasks — replication, quality of service, policy management and more — should be automated. Management tasks should be simplified enough that even non-experts can manage 32 VMstores and 100,000+ VMs from a single pane of glass.

3. **High Performance & Performance Isolation:** The storage solution should guarantee the performance of each VM with VM-level quality of service. Each virtual machine should be protected from the activity of other VMs within the same system — in essence providing immunity from the "noisy neighbors" problem.

4. **Automation:** Storage should support at-scale operation of APIs and other automation tools such as PowerShell. Users should be able to customize workflows, reducing the tedium, stress and inefficiencies that result from the expenditure of manual effort.

5. **Multi-Hypervisor Support:** From a VM-aware storage (VAS) perspective, a VM is a VM is a VM. The system should be hypervisor-agnostic, which means users should not need to carve out additional storage or budget for multiple workloads or multiple hypervisors.

6. **Analytics:** Administrators should be able to see the capacity, throughput and performance data for every single VM. Ideally, administrators will even be able to see the latency for each VM spanning the entire infrastructure, across host, network and storage. These analytics should display in real-time, and offer the ability to apply years of collected application behavior metrics to the accurate forecasting of future storage requirements.

7. **VM Scale-Out:** Scaling storage in the same way as scaling compute in a virtualized environment is critical for growing and maintaining a stable VDI environment. Built on Tintri's VM-aware Storage (VAS) platform, the Tintri VM Scale-Out software uses a million data points collected every 10 seconds from thousands of VMs to optimize VM distribution across multiple pools of storage.

Citrix VDI Capacity Program for Storage Partners

Citrix Ready® launched this program with many existing storage partners. The goal is to address the storage needs of customers who already have implemented or are considering implementing Citrix XenDesktop. VDI presents multiple types of data — each with its own unique requirements — to the storage infrastructure tier. Storage in turn can cope with these requirements using various hardware- and software-based approaches, some of which can be combined into hybrid solutions. As the number of storage options for VDI has steadily increased over the last several years, confusion has arisen for some customers who are still unsure as to which approach is right for them.

To help address this confusion, Citrix started this program — Citrix Ready® VDI Capacity Program for Storage Partners Phase II — with storage partners representing several different VDI workloads with their storage solutions. To participate in the program, the partner was required to set up a test environment with the necessary compute resources needed to generate a 1,500-, 3,000-, or 5,000-user XenDesktop workload.

As opposed to a traditional "benchmark," whereby different achievement scores are possible, this VDI Capacity program is a simulation of "a day in the life" of a XenDesktop farm supporting a certain number of users. If a partner's chosen storage solution can successfully support "a day's" run to the defined user capacity while sustaining required performance metrics, the partner passes and the validation test is concluded.

To demonstrate full compliance with Citrix standards, Tintri has chosen to take part in the Citrix Ready® program — a program specifically designed to address the storage needs of customers implementing XenDesktop. Tintri chose to validate the T850 Hybrid-Flash VMstore storage array against a 1,500-seat desktop virtualization environment based on XenDesktop 7.6. The end goal was to demonstrate the ability of Tintri to deliver a storage solution at an economical cost for an end user while consistently enabling an excellent end user experience. The program was not designed to test the limits of the storage system.

Test Methodology

The VDI Capacity Program is focused on provisioning the appropriate amount of storage capacity with a cost-effective design, while also assuring adequate VDI performance for customers implementing XenDesktop. A simple, binary pass/fail methodology is employed. The primary objective was to demonstrate the ability of Tintri hybrid flash storage to comfortably support 1,500 virtual desktops at a very economical per-user cost, while consistently delivering an excellent end-user experience.

Specifications of the test setup were as follows:

1. Chassis A (125 desktops per server, for a total of 1000 users):

- Servers used: 8 x Cisco Systems Inc UCS-B200-M4-PP
- Processors: 2 x Intel 2698 v3 (16 core at 2.3 gigahertz) per server
- 384 gigabytes of memory per server
- VIC 1340 adapters (included in Cisco servers)

Figure 1: Infrastructure configuration of hardware used

Component	Description	Quantity
Server model	Cisco Systems Inc UCSB-B200-M4-PP	8 servers
Processor(s)	Intel 2698 v3 (2 x 16 core @ 2.3 GHz)	32 cores per server
Memory	384	384 GB per server
Disk(s)	GB SAS @ RPM	N/A TB per server
Network adapter		VIC 1340 adapters
Storage array controller	controller GB cache	N/A controller per server

2. Chassis B (100 desktops per server, for a total of 500 users):

- Servers used: 5 x Cisco UCSB-B200-M3-PP
- 2 x Intel 2697v2 (12 core at 2.7 gigahertz) per server core
- 256 gigabytes of memory per server
- VIC 1240 adapters (included in Cisco servers)

Figure 2: Infrastructure configuration of hardware used

Component	Description	Quantity
Server model	Cisco UCSB-B200-M3-PP	5 servers
Processor(s)	Intel 2697v2 (2 x 12 core @ 2.7 GHz)	24 cores per server
Memory	256	256 GB per server
Disk(s)	GB SAS @ RPM	N/A TB per server
Network adapter		VIC 1240 adapters
Storage array controller	controller GB cache	N/A controller per server

A series of servers was dedicated to the launch infrastructure. Sixty launcher VMs were configured to handle 25 sessions each, simulating the end-points from which all users were connecting.

Login Virtual Session Index (Login VSI) is the industry-standard tool for VDI performance and capacity testing. This tool was used to generate VDI workloads and to measure performance using a pre-defined Login VSI "knowledge worker x 2vCPU" workload, which was run in baseline mode. The test load was designed to simulate typical daily knowledge worker tasks such as web browsing, viewing videos, sending and receiving emails, and managing documents via tools such as Microsoft Office. The binary result of pass/fail was determined by observing whether the storage system successfully met the storage demands placed upon it without reaching a latency limit known as VSImax.

The tests were designed to simulate 1,500 users connecting during a time span of 2,880 seconds (48 minutes), replicating the beginning of a typical work day. At the time of logon, each of the 1,500 unique user accounts grabbed a desktop from the pool. As each user logged on, the simulated worker would begin to "work" by performing one of the four segments of the knowledge worker test. Each segment of the test revolved around performing typical workaday tasks using popular desktop tools such as:

- Microsoft Outlook
- Microsoft Excel
- Microsoft Word (with a repository of 1,000 unique Word documents)
- Microsoft PowerPoint
- PDF viewers
- Web browsers

Figure 3: Login VSI Automatic Report

VSI response time @ 50 Sessions	712	VSI response time @ 800 Sessions	904
VSI response time @ 100 Sessions	750	VSI response time @ 850 Sessions	914
VSI response time @ 150 Sessions	786	VSI response time @ 900 Sessions	926
VSI response time @ 200 Sessions	772	VSI response time @ 950 Sessions	934
VSI response time @ 250 Sessions	803	VSI response time @ 1000 Sessions	951
VSI response time @ 300 Sessions	791	VSI response time @ 1050 Sessions	967
VSI response time @ 350 Sessions	818	VSI response time @ 1100 Sessions	995
VSI response time @ 400 Sessions	840	VSI response time @ 1150 Sessions	1032
VSI response time @ 450 Sessions	840	VSI response time @ 1200 Sessions	1055
VSI response time @ 500 Sessions	844	VSI response time @ 1250 Sessions	1083
VSI response time @ 550 Sessions	848	VSI response time @ 1300 Sessions	1106
VSI response time @ 600 Sessions	853	VSI response time @ 1350 Sessions	1113
VSI response time @ 650 Sessions	864	VSI response time @ 1400 Sessions	1167
VSI response time @ 700 Sessions	867	VSI response time @ 1450 Sessions	1189
VSI response time @ 750 Sessions	895		

Though random selection determined which of the four segments of the knowledge worker test each simulated worker would initially perform, every worker cycled through every segment of the test before test conclusion. The randomization built into the test was designed to better simulate actual user behavior, and served to mimic the unpredictable spikes of activity that would be a daily occurrence in a "real world" VDI environment.

Throughout the test, timestamps were recorded to a centralized location for every task performed within every VDI session. The timestamps marked both the initialization of each task and the corresponding point at which the system became responsive to the increased demand necessitated by commencement of the task. The final test report includes a summation of best times, worst times, and indexed averages from timestamps generated by all of the sessions.

Overview of Tintri

Tintri has focused exclusively on storage for virtual environments. The Tintri founders identified the clear mismatch between the approaches of traditional networked storage and the demands of virtualization. They saw a need for a more efficient shared storage model specifically designed for VMs. This sharp focus enables both pervasive simplification, as well as the intelligent application of key new technologies such as flash memory.

More than just optimized for VMs, Tintri operates natively at the VM level and makes a VM the core object of management within Tintri systems. Gone are legacy storage concepts such as LUNs, volumes, tiers, and RAID groups. Tintri provides storage that is custom-built to speak the virtualization language.

Tintri VMstore for Citrix XenDesktop

Tintri VMstore is a VM-aware storage solution designed exclusively for VMs. Traditional shared storage solutions require complex configurations, specialized knowledge, and are cost-prohibitive to deploy in virtual environments. With Tintri VMstore, administrators get simple, fast storage and can focus on managing VMs, not LUNs or volumes.

Tintri VMstore appliances run the Tintri OS, an operating environment designed to accelerate virtualization, delivering VM and vDisk-level management and monitoring. The Tintri OS intelligently and cost-effectively leverages flash storage to provide unparalleled performance for thousands of VMs. Tintri OS' per-VM replication functionality radically reduces administrative work for planning, monitoring, and making data protection policy changes, while providing high throughput for enterprise-scale data protection.

Put simply, Tintri VMstore does for storage what virtualization has done for servers.

Unique Offerings of Tintri VMstore

Tintri VMstore hybrid flash storage offers a number of innovative and unique features comprising a comprehensive package, the sum total of which are simply not available with any competing product.

The Tintri VMstore T800 hybrid flash series aligns storage with business needs — putting the focus on virtualized applications. Tintri's VM-aware storage speeds performance six times and packs storage 10 times more densely than VDI without a storage solution. The T800 hybrid flash series is ideally suited to multiple workloads and hypervisors, large (and growing) VDI deployments, and/or to a private cloud.

Offerings that are unique to Tintri VMstore include:

- **Simplified Management:** Every storage action may be performed at the VM-level. This provides the ability to manage, replicate, automate, and analyze any (or every) VM.
- **Common Operating System:** Tintri's all-flash and hybrid flash arrays share a common OS and analytics, enabling the balancing of workloads and the management of up to 32 VMstores from just a single pane of glass.
- **VDI Specific Storage:** Tintri builds VM-aware storage specifically for virtualized applications, eliminating the many inadequacies and limitations of traditional physical-first storage.
- **Ease-of-Use:** VMstore is a true set-and-forget system that relieves VDI administrators from all hands-on management tasks.
- **End-to-End Visibility:** Administrators are provided full visibility into the system. They have the tools to see how many VMs are online and what they are doing at any given time, isolating potential performance issues before they become real issues. This capability renders the system less susceptible to IO storms such as virus scans, boot-up sequences, etc.
- **Performance Consistency:** The solution provides fast performance with superior economics and consistent availability. Even if failover occurs, the replacement is of the same quality as the original.

Tintri VMstore has been validated by Citrix as a Citrix Ready® product. To date, more than 27,000 products have been validated as Citrix-compatible. Tintri VMstore has also been selected as a Citrix Ready® featured product.

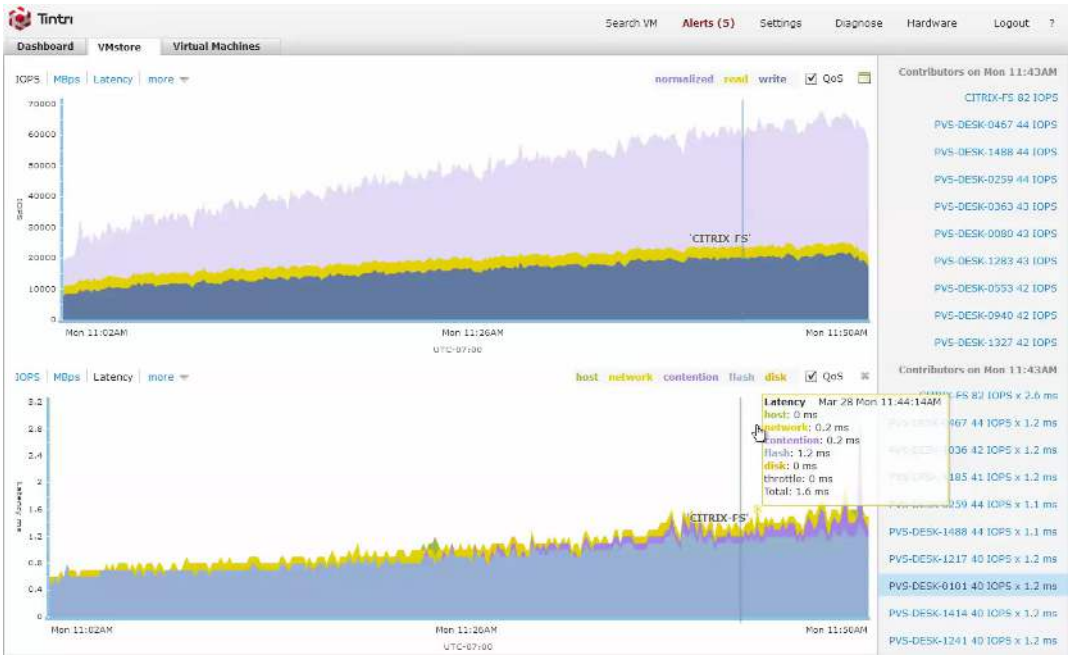
Overview of Results

Testing confirmed that Tintri T850 Hybrid-Flash VMstore storage array can easily support 1,500 virtual desktops as measured against the success criteria of the Citrix Ready® VDI program. Furthermore, the execution of this test clearly demonstrated that Tintri Hybrid-Flash VMstore storage can realistically support 1,500 desktops, with the test workload profile, at a compellingly low storage cost of $65 per desktop — a total cost that includes three years of support.

Please note that the AFA is a slightly pricier option, which adds expandability, predictable performance and can support more than 1500 desktops.

Less than 20,000 IOPS occurred during the course of testing. VMs launched at an average rate of 21.4 per minute.

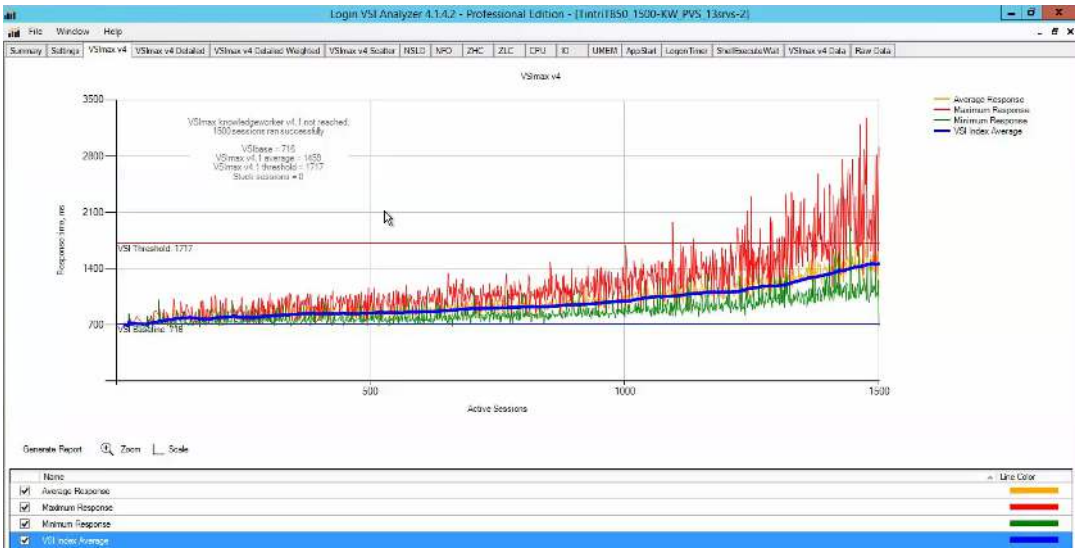
Figure 4: IOPS and Latency



Notable test results and performance metrics included the following:

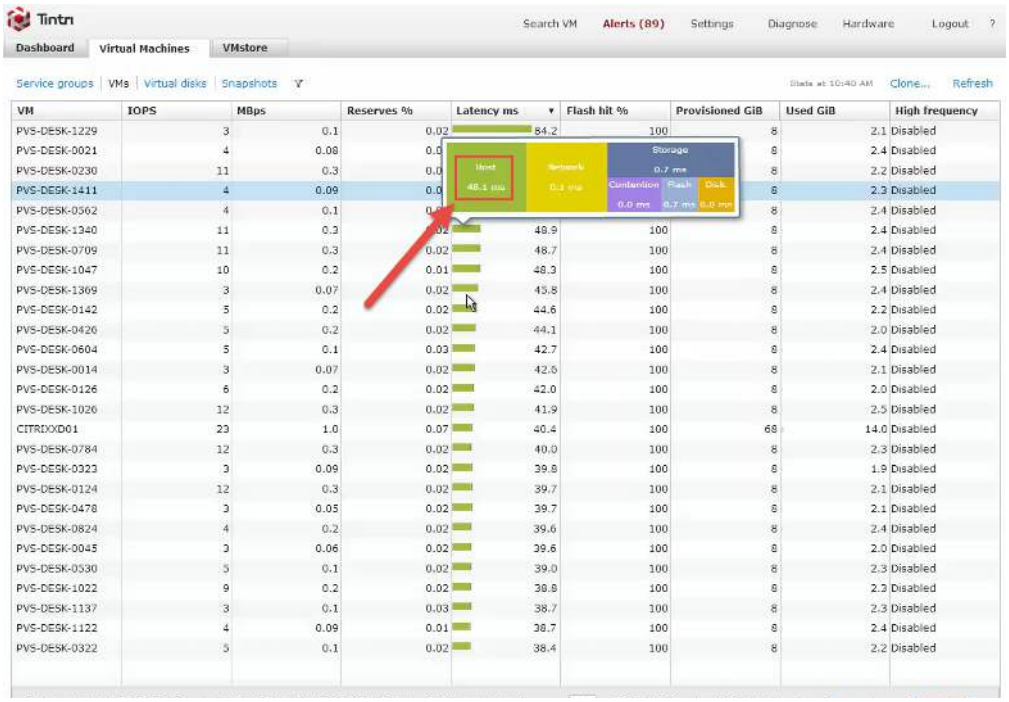
1. **Login VSI Data:** A total of 1,500 virtual desktop sessions were successfully launched and stress tested, running in benchmark mode as required by the Citrix Ready® program. The latency limit of VSImax was not reached at any point of the test. The VSImax average response time threshold was 1,717 milliseconds. The VSImax baseline average response time was 716 milliseconds. VSI response time threshold headroom was 1,857 milliseconds.

Figure 5: VSI Response Time



2. **End-to-End Latency:** The T850 enabled complete network latency visibility through a feature known as end-to-end latency — a capability unique to Tintri. End-to-end latency reveals latencies across every component of the entire infrastructure, including host, network, and storage. Throughout testing, end-to-end latency revealed latencies at a glance for every process, including VM requests, IO service time, etc. Any latency issues that occurred during testing were found to be the result of CPU oversubscription rather than storage-related bottlenecks.

Figure 6: Latency Bottlenecks



Latency isn't always a storage problem. Identify bottlenecks and their victims quickly.

Figure 7: IOPS and Latency

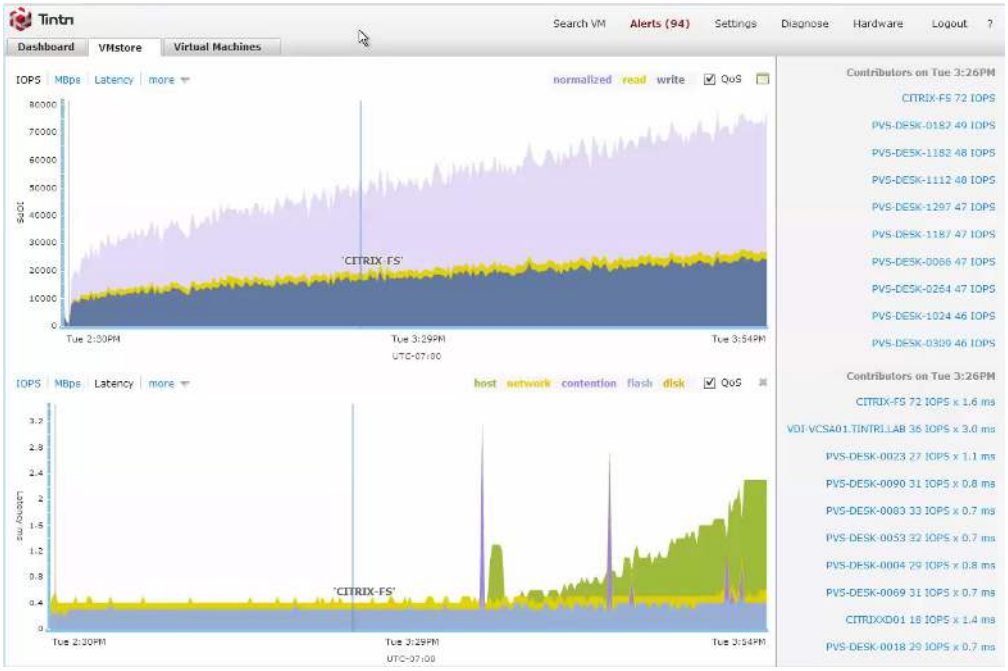
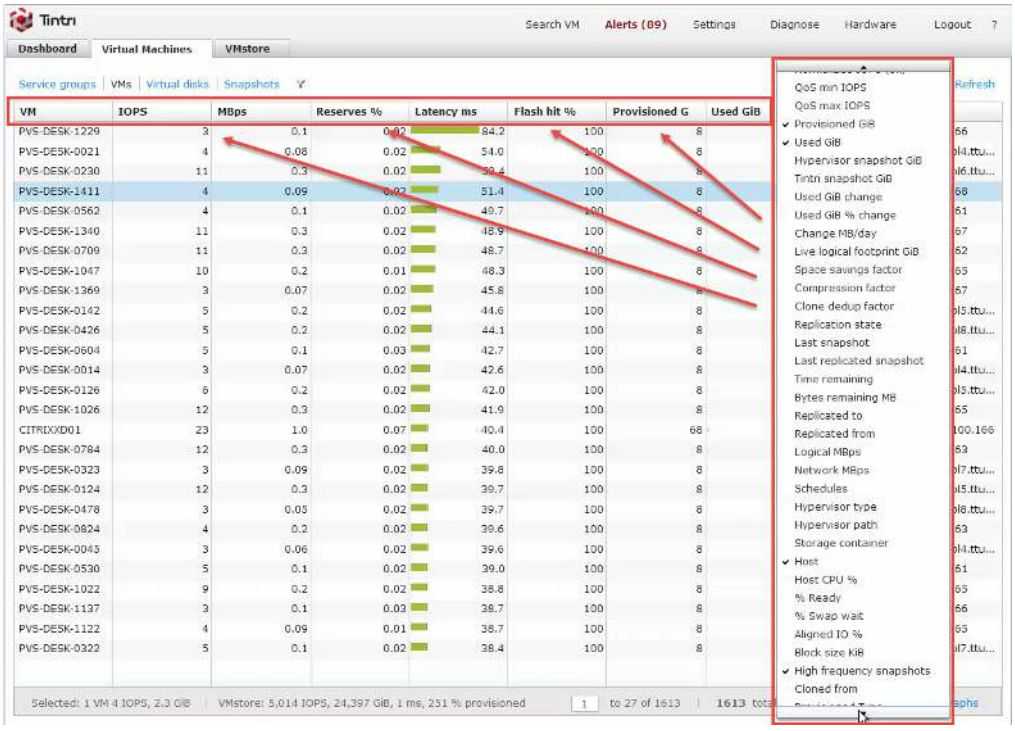


Figure 8: Granular Display

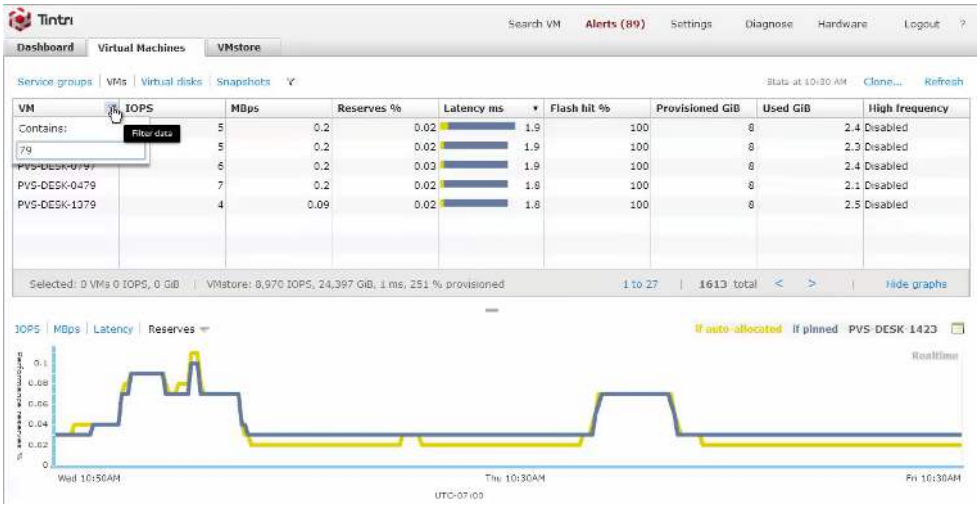
Amazing granularity... right down to each and every vDisk.

Figure 9: Choose Your Own Metrics



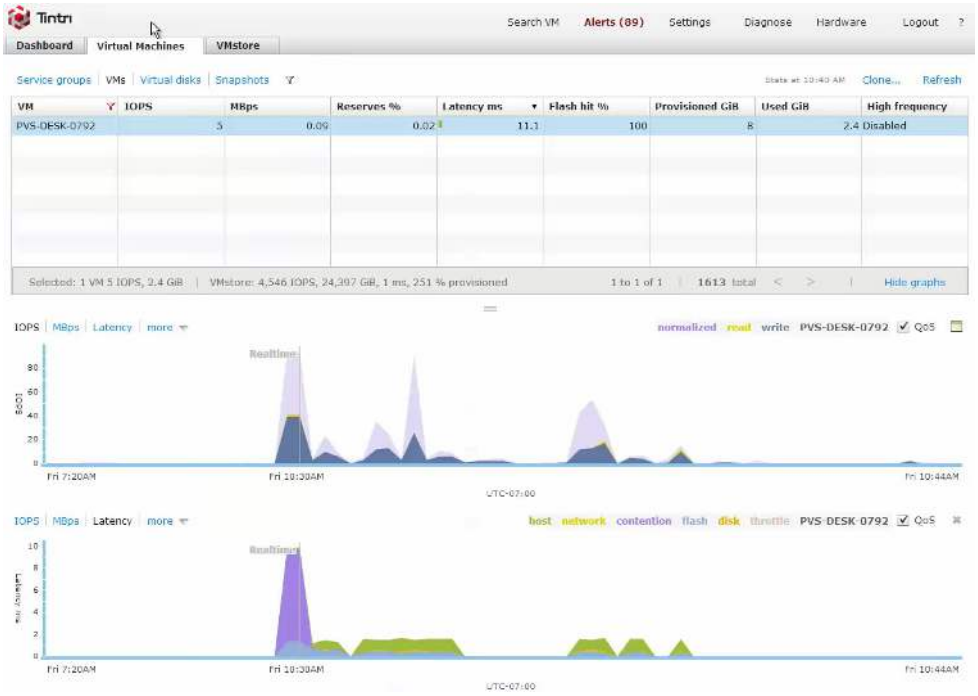
So many metrics to choose from.

Figure 10: Filtering



Quick and easy filtering.

Figure 11: VM Historical Trends



Historical trends... for every VM.

Figure 12: Test Results Overview

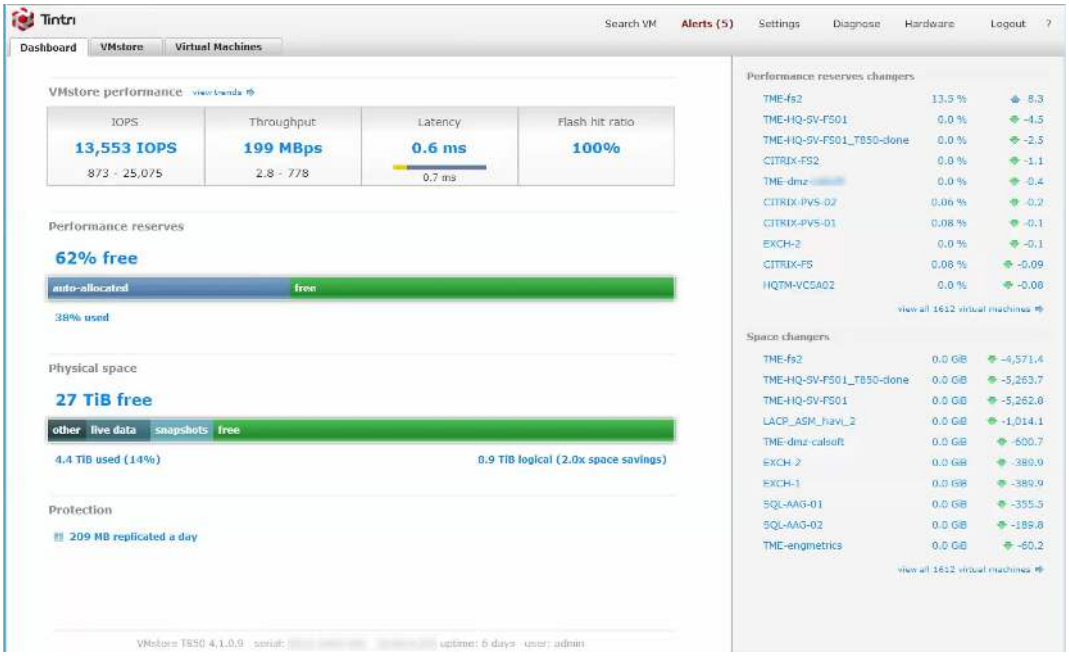


Figure 13: Virtual Machine Overview

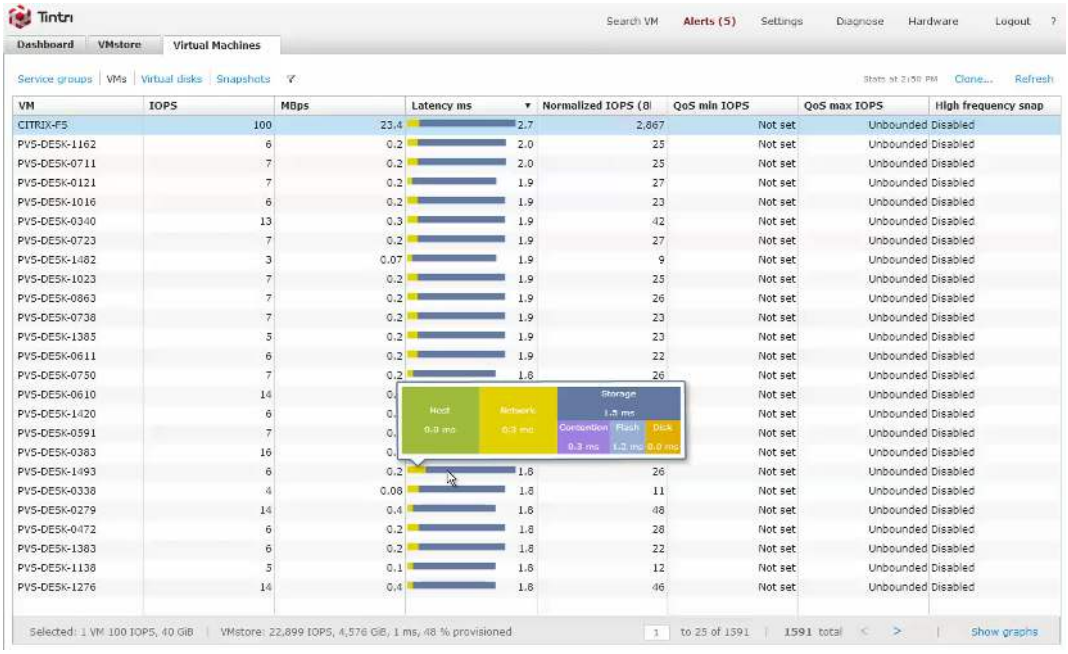


Figure 14: Average Logon Duration

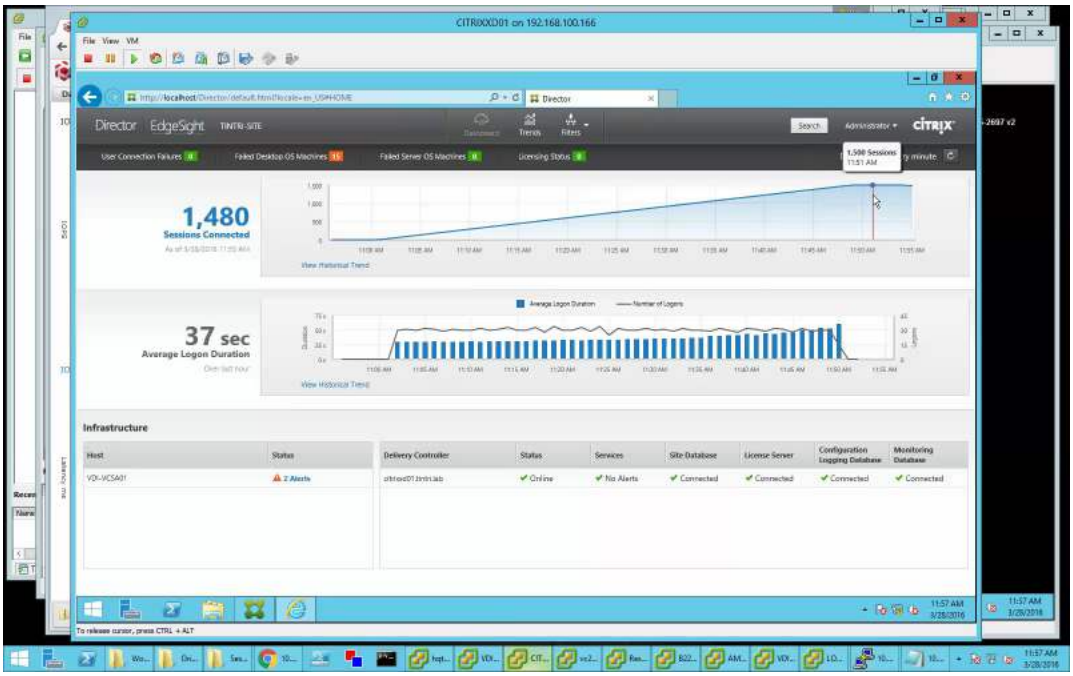
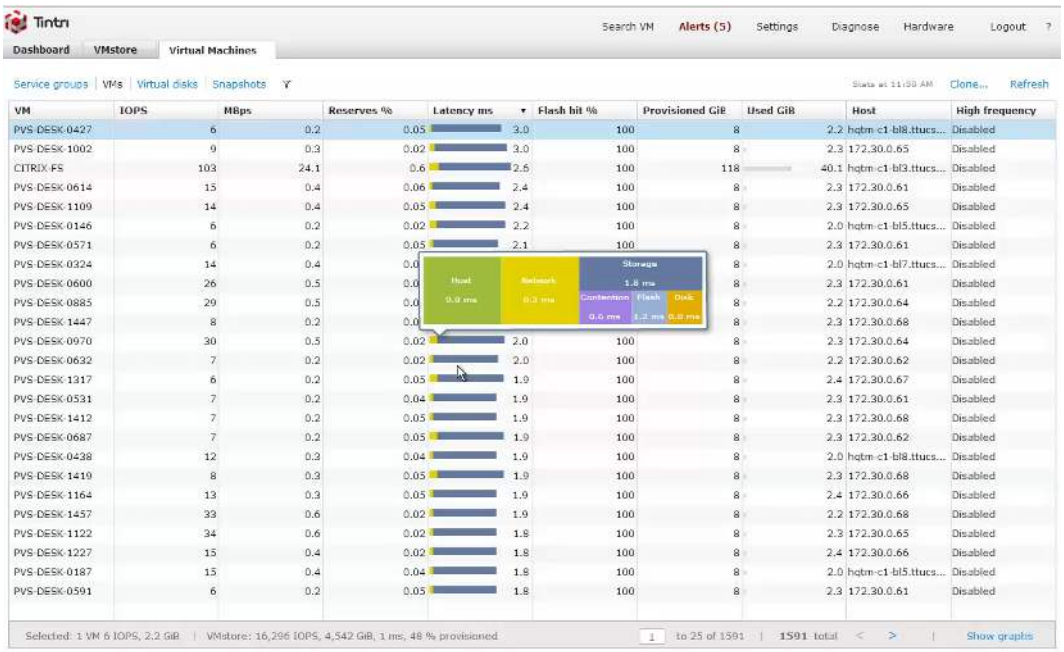


Figure 15: Latency Breakdown by Virtual Machine



Test Results Show Mutual Benefit

Citrix XenDesktop delivers full Windows VDI capabilities in addition to virtual apps, meeting the demands of any use case. XenDesktop enables users to access their apps, desktops and data without the limitations of a traditional solution. On the unified FlexCast Management Architecture (FMA) platform, XenDesktop is the only solution that is FIPS-compliant and Common Criteria certified to meet the highest security standards of regulated industries. End users will enjoy the simple virtual desktop interface, while IT will appreciate the superior performance of HDX technology, even when deployed over challenging, high-latency networks.

Tintri VM-aware storage is the simplest and most suited for virtualized applications and cloud. Global organizations including General Electric, Toyota, United Healthcare, NASA and seven of the Fortune 15 have said "No to LUNs." With Tintri they manage only virtual machines, in a fraction of the footprint and at far lower cost than conventional storage.

As demonstrated with Login VSI test results, Tintri T850 Hybrid-Flash VMstore storage clearly exceeds the benchmark set for the Citrix VDI Capacity Program. The test also confirmed that Tintri VMstore provides extremely high performance and capacity savings when deployed with XenDesktop virtual desktop VMs.

It should be noted, however, that Login VSI only tests a small subset of the factors that are key to a successful VDI deployment. Two primary influential factors are end-user experience and administrative/management complexity. Any VDI solution that improves end-user experience while reducing operational overhead will result in a superior deployment, and will bolster enhanced user and administrator acceptance. A byproduct of the Citrix VDI Capacity Program benchmark test was a clear demonstration that the Tintri T850 Hybrid-Flash VMstore storage solution can vastly simplify management requirements and deliver an unparalleled user experience.

As conclusively shown by the results of the Citrix VDI Capacity Program benchmark test, Tintri VMstore serves as a perfect symbiotic partner for Citrix XenDesktop, handily meeting or exceeding all the requirements of the Citrix Ready® Program.

For more information about Tintri and Tintri VMstore, contact Tintri. Stay abreast of Tintri news, tips and developments on Twitter: @tintri.

For more information about Citrix XenDesktop, contact Citrix Ready.

Appendix

For more information about the Citrix Ready® Program, visit: https://www.citrix.com/partner-programs/citrix-ready.html

For more information about Tintri Hybrid-Flash VMstore storage benefits for VDIs, please visit: https://www.tintri.com/solutions/vdi.

To learn more about how Tintri Hybrid-Flash VMstore storage improves XenDesktop deployments, please visit: https://citrixready.citrix.com/tintri.html.

To learn more about hybrid-flash storage for VDI, contact Citrix and Tintri.

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About Citrix Ready

Citrix Ready identifies recommended solutions that are trusted to enhance the Citrix Delivery Center infrastructure. All products featured in Citrix Ready have completed verification testing, thereby providing confidence in joint solution compatibility. Leveraging its industry leading alliances and partner eco-system, Citrix Ready showcases select trusted solutions designed to meet a variety of business needs. Through the online catalog and Citrix Ready branding program, you can easily find and build a trusted infrastructure. Citrix Ready not only demonstrates current mutual product compatibility, but through continued industry relationships also ensures future interoperability. Learn more at www.citrixready.citrix.com.

About Tintri

Tintri VM-aware storage is the simplest for virtualized applications and cloud. Organizations including GE, Toyota, United Healthcare, NASA and 6 of the Fortune 15 have said "No to LUNs." With Tintri they manage only virtual machines, in a fraction of the footprint and at far lower cost than conventional storage. Tintri offers them the choice of all-flash or hybrid-flash platform, converged or stand-alone structure and any hypervisor. Rather than obsess with storage, leaders focus on the business applications that drive value—and that requires that they keep storage simple. For more information, visit www.tintri.com and follow us on Twitter: @tintri