White Paper:
Virtual Desktop Infrastructure
How to Reduce Server + Storage Cost by 75%
Through a Hybrid RAM+SSD Cache
EXECUTIVE SUMMARY

Virtual Desktop Infrastructure (VDI) deployment challenges IT departments to deliver storage performance that satisfies the high peak I/O demands of 'usage storms' while keeping the total cost low. A hybrid RAM+SSD cache enables IT departments to meet that challenge by significantly reducing the storage costs and increasing the density of virtual machines in desktop virtualization deployments. It does so by empowering systems administrators to scale storage and IOPS independently. Compared to alternative methods of scaling performance, the hybrid cache delivers the best value.

INTRODUCTION

George Crump of Storage Switzerland and Gunnar Berger of Gartner have said that over 40% of IT spending on Virtual Desktop Infrastructure (VDI) is spent on storage¹. The driving factor behind storage costs for VDI is the need to meet the high peak IOPS burden on storage during 'usage storms.' These 'usage storms' are brief spikes in I/O levels and come in a few common varieties: 'boot storms' as users start their systems, 'login storms' as users log in to their systems, and 'A/V storms' as antivirus software scans the system.

IT departments thus face the puzzle of scaling storage performance to meet high peak IOPS demands of VDI while keeping storage costs low enough to justify VDI.

The VDI Storage Cost Problem

Virtual desktop usage storms occur in spikes a few times a day and have extremely high I/O performance demands. Normal 'steady state' use requires much lower IOPS levels.

The steady-state demand on storage is 6 to 50 IOPS* per virtual desktop. During a typical usage storm (a 'boot storm') demand on storage peaks at 300 IOPS* per virtual desktop.

A storage system, built to deliver the high peak IOPS required during usage storms is expensive and will be under-utilized 90% the time. A storage system optimized for steady state is cost-effective but will deliver poor user experience during usage storms. The trade-off between sizing storage for steady-state performance while meeting peak demands is the crux of the cost/performance problem in VDI.

Solving the problem cleverly can result in big savings. VDI optimization software addresses the issue and reduces server/storage cost by 71%.

¹These typical IOPS are from the Citrix Blog. Learn more at VMdamentals.

and http://www.enterprisenetworkingplanet.com/datacenter/vdi-daas-compete-for-desktop-dollars.html
‘Traditionally’ IT managers scale peak storage performance by adding more or faster hard drives – a cost-inefficient, hard to manage way to scale IOPS since it leads to unused disk capacity. Newer technologies such as optimizing storage I/O in RAM and/or SSD deliver much better price/performance and make VDI affordable.

One new approach to meeting the VDI performance requirement is a hybrid cache that uses a combination of RAM and an optional Solid State Disk (SSD) to provide high peak storage performance in a cost-efficient manner. A hybrid cache stands out as both the most cost effective and easiest to implement solution to the VDI storage challenge.

As the rest of this paper will show, a hybrid cache is the best way to reduce cost and increase density of virtual machines for desktop virtualization. In this paper we will explore three reasons why this is true:

1. Traditional methods for scaling (such as adding more hard drives or RAM to increase performance) don’t work for desktop virtualization.

2. A cache can be more effective than flash-based storage while achieving a higher cost efficiency.

3. A hybrid cache that utilizes a combination of RAM and SSD strikes the ideal balance of performance and cost.

Let’s dig into each of these points in more detail.

**TRADITIONAL SCALING METHODS DON’T WORK FOR DESKTOP VIRTUALIZATION**

The storage performance levels needed to service a 2000-user virtual desktop deployment are very high. The storage system needs to provide roughly 600,000 IOPS at peak usage (see The VDI Storage Cost Problem sidebar for IOPS levels per desktop). However the vast majority of its IOPS capacity is wasted during normal steady-state operation when only 12,000 to 100,000 IOPS are used. To keep the storage cost per virtual desktop at $150 (approximately twice the price of a laptop hard drive), the storage system would need to provide 600,000 IOPS / $150 = 4000 IOPS/dollar. The traditional methods of scaling performance, described below, attempt to satisfy the high performance demands for VDI but cannot do so cost effectively.
The solution that seems simplest to meet high IOPS levels is to add more disk spindles to your VDI infrastructure. Each inexpensive SATA drive adds only 75-100 IOPS, but you need tens of thousands of IOPS to satisfy I/O storm levels. That implies buying several hundred or thousand SATA drives for a medium-sized VDI deployment. Adding more disk spindles just to get the IOPS leads to a lot of unused/wasted disk capacity. It’s clearly too expensive and inefficient to scale performance by buying SATA hard drives.

Say you aren’t quite so simpleminded and you improve upon the previous approach by putting primary data on faster drive technology like solid state drives / flash memory or 15k rpm SAS drives. With the faster drives you have tons of IOPS capacity available – enough to satisfy the highest IOPS demand during a usage storm. But for the other 23 hours of the day the I/O demands are much lower. Instead of wasting space capacity (like the first approach did) now you are wasting IOPS capacity. Again you have spent money to buy a system that is overkill for VDI.

Adding more RAM is another common solution to performance problems. With this approach, improvement is short-lived. The main I/O load during a boot storm is created when guests (virtual desktops) retrieve their OS images from disk. Environments where each guest must access the physical disk independently experience a lot of random-access I/O. Adding RAM does not improve storage read speeds so it will not accelerate the retrieval of the OS image from disk.
Although adding system RAM may not help with the boot storm, there is a situation where using RAM can help. The next section in this paper explains how adding RAM as one component of a system-wide cache architecture can help reduce VDI costs while significantly increasing performance.

**A CACHE IS MORE COST-EFFICIENT THAN FLASH-BASED PERMANENT STORAGE AND CAN BE SUPERIOR AT IMPROVING PERFORMANCE**

Caches are used to speed up access to data. A cache is a high-speed component placed in front of a slower data-storage, processing, or networking device to transparently store data so that future data requests can be served faster. As data passes through a cache on its way to or from the storage/processing/networking device, some of the data is selectively stored in the cache. When an application or a process later accesses data stored in the cache (a cache hit), that request can be served faster from the cache than from the slower device. The more requests served from cache, the faster is the overall system performance. When there is a predictable data access pattern, such as in VDI, a cache offers the most cost-effective means to boost performance. Caches are simple to manage, because the caching software automatically and transparently selects which data to store on the faster storage.

A caching approach to VDI storage acceleration is safe and easy to manage. The cache automatically identifies the most frequently accessed (‘hot’) data and accelerates access to it. You do not need to monitor what data is hot. For example as users change projects different data becomes ‘hot’ data. Additionally the cache merely holds a copy of the data so there is no data loss in the event of a cache failure and existing data protection systems still work without any reconfiguration.

In contrast an all-flash storage configuration that stores primary data has these negative attributes that caches do not:

- the administrative overhead of tracking capacity, performance, and reliability,
- the risk of data loss if some SSDs fail, and
- the additional costs of redundancy, like RAID overhead and backup.

The ever-growing amount of master images and user data drives up required storage capacity. In flash-based storage, where primary data is on flash, scaling is achieved by adding more of the expensive flash storage. In a cache-based system storage capacity is scaled by adding inexpensive spinning media, thus storage and IOPS may scale separately, which keeps storage costs low in a caching configuration.
When used as a cache the amount of SSD needed is less than when used to store all primary data. That means that caching reduces overall storage cost enabling information technology departments to provide virtual desktops using a smaller budget. In fact caching can provide significant ROI with a deployment of just a few dozen virtual desktops. An all-flash array on the other hand requires thousands of virtual desktops to justify its cost.

VeloBit has found that caching using RAM and flash can significantly outperform an all-flash-based storage configuration without increasing cost. VeloBit compared a transaction processing benchmark (similar to TPC-C) of an all-flash data storage system to a caching system that combines RAM and flash in similarly priced configurations (see below table for details). A large Fusion-io PCIe flash card was used for the all-flash storage test. For that test, the benchmark reached 4,874 TpmC. For the VeloBit flash + RAM caching system, the results were 8,621 TpmC (76% more). The cache was able to achieve higher results because of the superior performance characteristics of the RAM portion of the cache. Even better results could be expected from a cache in a VDI environment because VDI results in higher cache hits than databases.

<table>
<thead>
<tr>
<th>Flash Storage Configuration</th>
<th>Caching Configuration</th>
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<tbody>
<tr>
<td>Primary data storage</td>
<td>Fusion-io, 1.2 TB ioDrive Duo</td>
</tr>
<tr>
<td>Cache</td>
<td>None</td>
</tr>
<tr>
<td>Cost</td>
<td>$20,000</td>
</tr>
<tr>
<td>TpmC (performance)</td>
<td>4,874</td>
</tr>
</tbody>
</table>

Most hypervisors do not have a native ability to cache guest data. This is a missed opportunity for improving price-performance and lowering the overall CAPEX of VDI. With a cache-enabled hypervisor multiple VMs could boot from the same ‘master image’ while accessing the primary storage device only once. The master image would be cached locally and made available to all VMs. That would lower the IOPS load on the storage while lowering virtual desktop boot time – a win-win storage approach.

Some commercially available VDI software offers caching capabilities, but these products have limitations. For example, VMware View’s Content-Based Read Cache (CBRC) only updates its caching block digest of the VMDK file when guests are powered off, so the CBRC lags the actual VMDK data. This leads to lower cache hit rates and lower effectiveness of the cache. In another example, Citrix Provisioning Server caches master images on a server separate from the hypervisor host server. This separation leads to network congestion as the master image data is repeatedly transferred to the hypervisor host.
This section showed that a caching approach is safer and easier to manage than an all-flash storage system. In addition, a cache can provide double the price-performance of a storage system that is made entirely of flash memory. As you would expect there are a variety of cache approaches to consider deploying and the next section explains your options.

**A HYBRID CACHE PROVIDES THE BEST VALUE**

Using a cache to speed up virtual desktops is simpler to operate and less expensive than using flash memory to permanently store virtual desktop data. To get the most value out of a cache it is important to choose a caching architecture that suits the unique demands of virtual desktops.

VDI deployments need a cache that is both high performance and able to scale. Usage storms necessitate the cache to deliver high performance to keep up with the high intensity of I/O requests. And the cache must be able to scale its capacity because the amount of data that needs to be cached increases over time. (The data growth is driven by master image proliferation, users creating and accessing more data, and changing projects.) Keeping more data in the cache will nearly always improve performance, so having a large cache is beneficial to performance in general.

When selecting a caching architecture you can choose RAM-only, SSD-only, or a combination of RAM and SSD (a “hybrid cache”). A RAM-only approach provides hundreds of thousands of IOPS of performance but breaks the bank at cache sizes needed for VDI deployments. An SSD-only approach is an order of magnitude slower than a RAM cache, but is 75% cheaper and can deliver high cache capacity. A hybrid cache combines an SSD with a modest amount of RAM, delivering a blended system with the best attributes of both.

The algorithm used by a hybrid cache places the ‘hottest’ data in the RAM portion and ‘hot but not hottest’ data in the SSD portion. That methodology provides the extreme performance of a RAM cache for the most-frequently-accessed data and also allows for a large, fast SSD cache for cost-effective cache expansion. A hybrid cache can also operate in RAM-only mode when no SSD is present. In RAM-only mode installations can cost-effectively start with a small RAM-only deployment and add an SSD later to scale the cache capabilities. The hybrid cache is the only cache architecture that is simultaneously high-performance, scalable and relatively inexpensive.
HYBRID CACHE PERFORMANCE BENCHMARK AND COST ANALYSIS

To demonstrate the impact that hybrid caching can have on a VDI deployment VeloBit ran the Login Virtual Session Indexer (Login VSI) benchmark to simulate real-world VDI loads on a system with and without VeloBit vBoost, a hybrid caching software solution.

What About Tiering?
A good caching technology meets or exceeds the performance of tiering solutions while avoiding the data management complexity associated with tiering.

Login VSI is the de-facto industry standard benchmarking tool to test the performance and scalability of centralized Windows desktop environments like Server Based Computing (SBC) and Virtual Desktop Infrastructure (VDI). The test used the ‘medium’ workload. The medium workload simulates a knowledge worker by opening and using up to 5 apps simultaneously. The test also includes idle time to simulate real-world users. Login VSI medium workload uses Outlook, Internet Explorer, Word, Bullzip PDF Printer, Acrobat Reader, Excel, PowerPoint, and 7-zip.
Login VSI results without VeloBit’s caching, showing response times as desktops are added to the system (note the scale on the bottom and VSI_max of 46 desktops)

Login VSI results with VeloBit’s caching, showing response times as desktops are added to the system (note the much higher scale on the bottom and VSI_max of 226 desktops)
The VeloBit configuration resulted in server + storage cost per virtual desktop of $124, which is 65% lower than the baseline configuration. (You can see the cost breakdown excluding some licensing fees in the below table.)

<table>
<thead>
<tr>
<th></th>
<th>Baseline (no caching)</th>
<th>VeloBit vBoost (caching)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Desktops</td>
<td>47</td>
<td>226</td>
</tr>
<tr>
<td></td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td></td>
<td>$ per Desktop</td>
<td>$ per Desktop</td>
</tr>
<tr>
<td>Server</td>
<td>$10,142</td>
<td>$10,142</td>
</tr>
<tr>
<td>RAM</td>
<td>$6,102</td>
<td>$6,102</td>
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<tr>
<td>HDD</td>
<td>$400</td>
<td>$400</td>
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<tr>
<td>Caching SW</td>
<td>N/A</td>
<td>$11,300</td>
</tr>
<tr>
<td>TOTAL</td>
<td>$16,644</td>
<td>$27,944</td>
</tr>
<tr>
<td></td>
<td>$354</td>
<td>$124</td>
</tr>
</tbody>
</table>

**HOW TO TRY A HYBRID RAM+SSD CACHE**

If you are interested in getting started with hybrid RAM+SSD caching you can try caching software for free. VeloBit offers a free download of the full product. You can get the software from [velobit.com](http://velobit.com).

The next steps to try it out are:

1. Attach an SSD to the server that you want to run the test on.
2. Use a vendor-independent VDI benchmark such as Login VSI (free version simulates only up to 50 users) to simulate a number of virtual desktops and compare the performance of the server before and after the caching software is installed.

Depending on your configuration you should be able to increase of the number of virtual desktops by 300% to 700% while delivering higher user responsiveness.

**CONCLUSION**

Using the right solution to solve the VDI IOPS problem can bring desktop virtualization costs down to a reasonable level. Deploying a hybrid cache is the most cost-effective way to provide the VDI IOPS necessary to handle usage storms. It's pretty easy to get started with caching, so give it a try today.
VeloBit vBoost is VDI storage optimization software that accelerates Citrix XenDesktop deployments by improving how Hyper-V hypervisors interact with storage. VeloBit lowers the hardware cost of virtual desktops to less than $100 per desktop, makes virtual desktops perform faster than PC’s, and deploys seamlessly in less than 10 minutes.

Learn more about VeloBit

Free Trial

See a Demo

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