Federal Data Center Consolidation Initiative (FDCCI) Whitepaper

VIRTUAL INSTRUMENTS

How Virtual Instruments SAN Optimization Best Practices Support Data Center Storage Consolidation Initiatives

Introduction

The reported number of Federal data centers grew from 432 in 1998 to more than 1,100 in 2009. This growth in redundant infrastructure investments is costly, inefficient, unsustainable and has a significant impact on energy consumption. In 2006, Federal servers and data centers consumed over 6 billion kWh of electricity, and without a fundamental shift in how this technology is deployed, it could exceed 12 billion kWh by 2011. In addition to the energy impact, information collected from agencies in 2009 shows relatively low utilization rates of current infrastructure and limited reuse of data centers within or across agencies. The cost of operating a single data center is significant, from hardware and software costs to real estate and cooling costs. The Federal Data Center Consolidation Initiative aims to address these challenges by leveraging best practices in the public and private sector.

Storage and storage networking consumes a huge proportion of datacenter footage and energy consumption. Virtual Instruments develops optimization solutions for managing the growth and design of storage and storage area network (SAN) -related technologies. These solutions are being deployed around the world in some of the largest datacenters, and through our experience, we can offer insight on best practices for speeding consolidation while mitigating risks and improving service levels. This paper highlights some of the challenges you will face and how Virtual Instruments can help Federal Chief Information Officers with the FDCCI.

SUMMARY

How VI best practices can help:

- **Drastically reduced risk of performance problems due to consolidation, new infrastructures, and storage tiering**

  Reports on metrics that provide definitive, real-time measurement of the effect on application latency, of any and all configuration changes

- **Single pane of glass for SAN health monitoring**

  Provides all the required information on a single dashboard to clearly show whether an application performance problem is with the SAN or not, for real-time root cause analysis. Provides historical performance, error, alerts and event trending information for end-to-end application I/O conversations

FDCCI – managing the growth of data centers

The FDCCI aims to address the growth of data centers and assist agencies in leveraging best practices from the public and private sector to:

1. Promote the use of Green IT by reducing the overall energy and real estate footprint of government data centers
2. Reduce the cost of data center hardware, software and operations
3. Shift IT investments to more efficient computing platforms and technologies
4. Increase the overall IT security posture of the government

As you will see in this paper, Virtual Instruments can help you to implement best practices in the first three of these goals. But first, we would like to further review the challenges inherent in this initiative as it relates to storage and storage networking.

FDCCI challenges for storage networks

Growth challenge	Storage capacity is increasing rapidly, but IT head count isn't. Consolidation itself will eliminate some inefficiency, but the truth is, most "fat" has been trimmed long ago. Chronic over-provisioning of capacity and storage network links, partially due to uncontrolled growth, will remain a key issue and is not likely to be significantly affected unless other changes are made to planning and reporting.
Complexity challenge	Consolidation alone will not add a reporting capability that ties infrastructure to quality of storage service delivered to applications. In fact, storage- and server-consolidation initiatives traditionally simplify the asset layer but move complexity of storage management to server infrastructure, with no net difference in overall effort. Server virtualization is a key example of complexity, since to benefit from this requires a shared storage pool for vMotion, DRS, etc. This makes ensuring that each application gets the quality of storage service required more difficult, not less. Mastering the different interfaces and intricacies of many point tools that don't talk to one another hugely impacts productivity and makes it difficult to handle the consolidated storage capacity. With consolidation, you increase the need to establish a concrete method for validating interoperability and performance on new or changed SAN devices – before introduction to the production environment.
Troubleshooting challenge	Changes have overtaken many IT administrators with silent footsteps. While the IT practitioner's every day is a swim through waves of invisible bits, there has long been some comfort to be found in the "physicality" and accessibility of key devices. Infrastructure consolidation will create more interdependencies between systems. For a given application, dependencies may cross multiple other applications, servers, SAN fabrics, IO adapters, and network hops. When the performance limit of a single component in one of these systems is breached, experience indicates that these I/O laden systems will not see performance gradually degrade, but rather will see latency and performance rapidly spiral out of control under a bombardment of increasingly delayed, dropped and repeated IO

- **Quick resolution of performance or component issues for highest availability**

  Alerts based on trends or thresholds quickly enable IT administrators to pinpoint performance issues and intermittent failures and take the appropriate action(s) to correct the problem

- **More cost-effective network provisioning**

  VirtualWisdom helps reclaim underutilized SAN ports to save on acquiring additional expensive core switch ports, storage ports, related cables, and SFPs.

- **Private cloud enabler**

  Enables IT to monitor I/O through the veil of virtualization, reducing the risk of deploying cloud topologies

	attempts that can no longer be queued, cached, backed-off by congestion controls, or otherwise gracefully handled. Consolidation alone will bring no view into which specific storage infrastructure issues are impacting application performance.
Virtualization / private cloud challenge	When problems arise, we have always been able to identify a switch port for examination, a server at the end of a wire that might be causing problems, an HBA for inspection, or any number of other physical things we can turn to for further examination. But in a datacenter that uses virtualization and private cloud technologies to achieve cost reduction and speedier provisioning, that comfort has vanished. In part, this is due to the virtualization of technologies surrounding us, and while this trend is spearheaded by server virtualization, the variations can include the likes of application virtualization, network device virtualization, I/O virtualization, and storage virtualization. While consolidation is dependent on the increase of server consolidation ratios, it is difficult to deploy virtualized mission critical applications due to a limited ability to see into the I/O subsystem. Risks are increased due to a limited ability to troubleshoot; as there is no real view into which specific storage infrastructure issues are impacting application performance. Because of a collapsed and centralized applications infrastructure, server admins may take more responsibility for more of the “stack”, most likely with the tools they are familiar with today. And these tools are largely blind to I/O. In a consolidated datacenter using virtualization techniques, isolated workload peaks can cause resource conflicts, and the concentration of load can create new and potentially more serious bottlenecks. The use of service-level agreements (SLA’s) for applications is not possible without the ability to measure and provide metrics for the full data path from server to disk system.
Storage network infrastructure challenge	A new, consolidated data center will inevitably include new, faster network infrastructures to support the greater I/O demands. While these networks are potentially beneficial from a performance perspective, transitioning to higher speeds creates some real challenges for SAN architects. In particular, there is a potential for increased data communication error rates that may result in disruption or performance degradation of mission critical applications. The physics of high-speed communication creates many new restrictions on crucial physical-layer elements such as optical cabling and optical modules. These restrictions must be understood, addressed and proactively monitored before the full value of faster infrastructures can be realized. Further, If increasing network speeds just causes other components to become bottlenecks, this can force additional unexpected expenditures (maybe faster storage, like SSD to utilize the network) fueling the ‘upgrade cycle’ and even higher costs.

Next generation datacenter storage networks

The evolution of storage networking technology is now making it possible to better align applications within a data center with the most cost-effective storage technology. Some of these storage technology innovations include:

1. Solid state memory disks
2. Multiple physical disk technologies (e.g. Fibre Channel and SAS) within a single storage array
3. Improved performance (IOPs, bandwidth) and data protection features (e.g. asynchronous replication, copy-on-write snapshots) of tier 2 storage arrays
4. Improved, application-aware tiering management software
5. Virtualization of physical storage
6. Private cloud, service-oriented management model

Related to the first five innovations – it is often possible for example, to take a tier 1 application and assign it to tier 2 storage, since the tier 2 storage technology often has the functionality to meet the mission requirements (e.g. replication, snapshots and RAID protection) of the application. And you can guarantee that performance meets SLAs by measuring the effect of I/O performance on application latency.

Denser, tier 2 storage presents a smaller footprint, uses far less energy, costs less to acquire, and is usually less expensive to maintain and support. In a Gartner-assisted analysis, we found that large agencies can save between approximately $7,000 and $10,000 per TB with a performance-based tiering strategy. This was based on energy costs of $.10 per kWH, floor space of $166 per square foot, and storage acquisition costs generally available to agencies through normal procurements.

Related to the fifth and sixth innovations – according to Gartner, "the primary benefit of private cloud computing is speed. Implementing a service catalog that offers standard services through a self-service interface, and automating the delivery of those offerings, can increase the speed of delivery dramatically. By themselves, standards, automation, and some form of resource pooling or virtualization will also reduce costs — but these can be done without building a complete private cloud." Though not absolutely tied to private cloud computing, virtualization is an enabler in the majority of cases, especially when combined with consolidation initiatives. Virtualization has proven to reduce costs, while at the same time accelerating the speed which new applications can be brought online.

How Virtual Instruments' can help with data center consolidation

Virtual Instruments offers a Virtual Infrastructure Optimization (VIO) solution that holistically assesses the entire physical and/or virtual infrastructure, and provides the IT staff with the data necessary to make intelligent decisions about capacity, utilization, and performance for every layer of the I/O infrastructure – from the host to the storage. Components and use cases of our solution include:

Monitoring and Measurement Best Practice

Rapid increases in the consolidation, operating speeds and general complexity of SAN technologies, exacerbated by the high change rates demanded of large IT organizations, significantly increase demands on the fiber optic physical layer.

A best practices-compliant physical layer must be capable of being both *maintained* and *monitored* in order to meet those demands. Physical layer maintenance requires the ability to quickly and easily add, change, or remove links and devices. Monitoring ensures the accuracy of the changes and validates that they produce only the desired results. Physical layers that address both requirements enable the Fibre Channel SANs operating on top of them to be iteratively optimized for maximum availability, performance, and utilization.

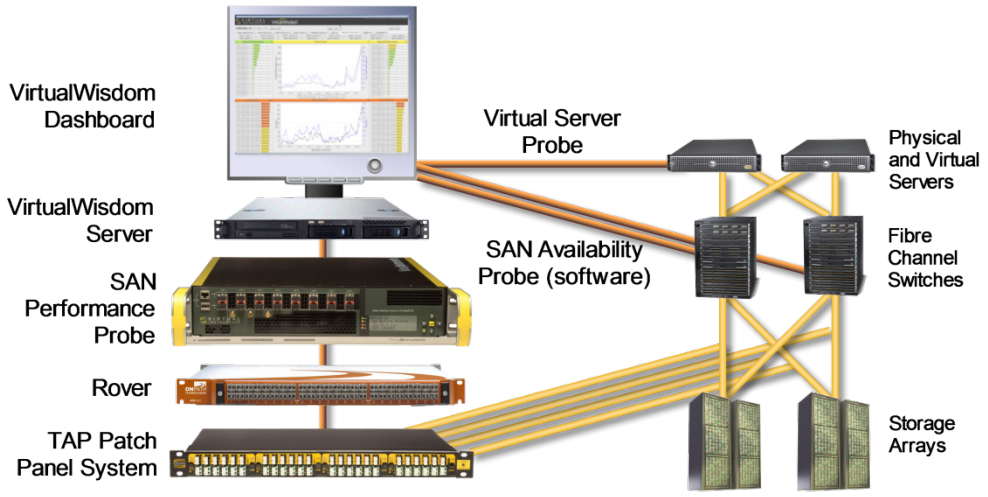
"With visibility in mind, access should be a "built-to" specification for all new data center infrastructure. Visibility is a mandatory best practice in the consolidating infrastructure, and you should therefore introduce improved visibility with every major system change."

Taneja Group 2010

Physical layer monitoring and measurement is the real-time acquisition and correlation of error, performance, and utilization data. This is enabled via optical splitters, called Traffic Access Points, or TAPs that allow passive access to this real-time data, and by probe instrumentation that analyzes the fibre channel frames. Virtual Instrument's SANInsight TAP Patch Panel System and VirtualWisdom SAN Performance Probe provide a range of options for monitoring and analyzing SANs.

"As a best practice, it's advisable for larger datacenter managers to install Fibre Channel network TAPs and monitoring software to generate real time, granular transaction data when moving to new infrastructures."

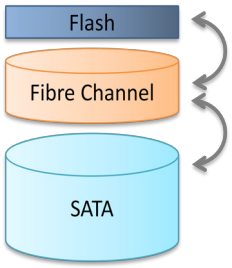
Eric Slack
Storage
Switzerland
2010



VirtualWisdom TAP and SAN Performance Probe

By unifying TAP and patch functions into a single layer of physical infrastructure, SANInsight significantly reduces the cost, complexity, and infrastructure impact of monitoring and measurement. SANInsight facilitates the broad installation of TAPs into both new and existing physical infrastructures, fully addressing the best practices monitorability requirement and enabling complete SAN optimization.

Tiering Management Best Practice



Virtual Instruments VirtualWisdom® is the missing puzzle piece of the tiering value proposition. Drive speed is only one factor in achieving the desired application performance for a storage tier and is often the smallest, most expensive performance differentiator. VirtualWisdom tracks I/O conversations to provide both real-time monitoring and trend analysis of overall performance between applications and all components of the Fibre Channel SAN – the host HBA, switches, virtualization appliances, storage ports, and LUNs. Combined with the storage vendor tools with their emphasis on storage system metrics, VirtualWisdom provides the critical missing data to enable IT organizations to more confidently use lower cost storage to provide higher tier performance. Virtual Instruments adds application latency data and other information to properly plan and optimize the environment. This is combined with alerting capabilities to prevent user impact as demands change, enabling IT to realize huge CAPEX improvements while delivering on SLAs.

With Virtual Instruments, you are instrumenting and measuring your infrastructure to provide your organization with all of the critical information needed to reduce power consumption, air conditioning, and floor space requirements related to your SAN and virtual server infrastructure. Savings are primarily due to reduced over-provisioning and more effective use of storage. You can see total savings in the range of $7,000 - $10,000 per terabyte of storage by utilizing performance-based tiering.

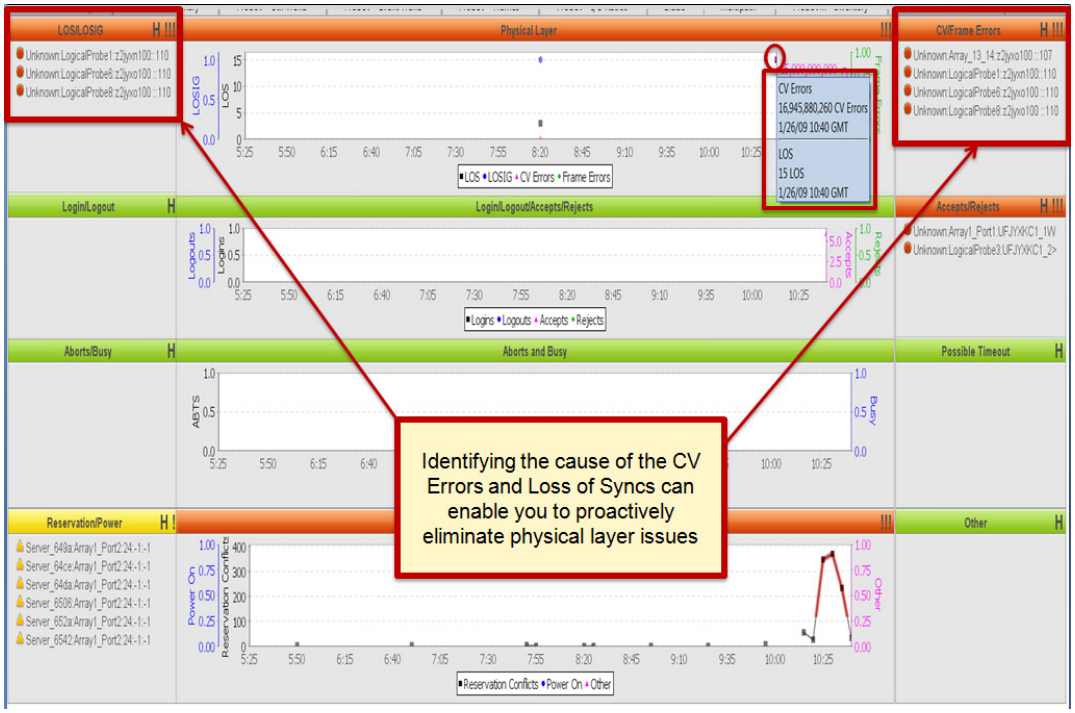
High Availability Best Practice

Beyond adding full I/O path awareness to let IT make more intelligent performance-based tiering decisions, VirtualWisdom also provides deep, physical-layer knowledge of the fabric to enable

actual problem avoidance, accelerate troubleshooting, and help de-risk the move to a consolidated computing model.

Monitoring the IT infrastructure reduces downtime by finding hidden problems. Every network has hidden issues, from physical layer errors to configuration and load-balancing issues such as failed multipathing. By setting alerts keyed to these issues, administrators can proactively eliminate them while they are still benign, making IT administration a proactive activity rather than a series of firefighting drills. Due to the robust nature of Fibre Channel SAN technology, most problems that impact users are compound issues, thus root cause is often hard to pinpoint. Being able to effectively address potential issues before application users report problems creates a more methodical and efficient process of ensuring application availability.

In the example VirtualWisdom dashboard below, there are enabled SAN ports with nothing connected to them. This can cause millions of code violations, creating a massive CPU overhead on the SAN switch. Finding these code violations enables proactive avoidance of many application slowdowns.



VirtualWisdom dashboard example

Problem Resolution Best Practice

Decreasing time to problem resolution is accomplished by monitoring transactions from the physical or virtual host to the LUN with VirtualWisdom. The ability to rapidly zero in on the source of the problem, proving within minutes whether the SAN is to blame for slow application performance or not, focuses the right team on the task and allows other teams to remain focused on other mission imperatives. Running historical reports to look back in time enables faster time to problem identification and resolution. In many cases, with VirtualWisdom you can “capture” the moment of failure, reducing the overall time to discover the root cause. Virtual Instruments’ customers often nickname this “DVR for the SAN”. VirtualWisdom is the only product that can monitor and send an alert about storage access times, congestion, link errors, and SCSI errors, and generate trend reports that show the behavior of a heterogeneous SAN, by host and by application. This information helps to dramatically expedite troubleshooting and allows the IT Manager to prove whether the problem is in the SAN, the application, or the server. This simple first step speeds troubleshooting by days, weeks, or even months.

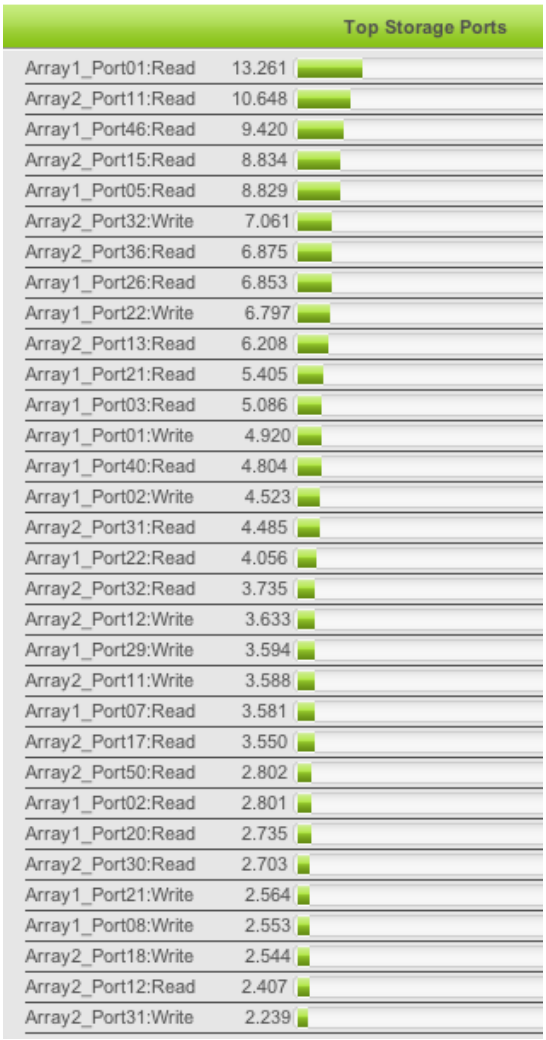
In the following screenshot, utilization trends are shown, from a SAN recording.

VirtualWisdom dashboard, showing trends from a recording of transactions

Network Provisioning Best Practice

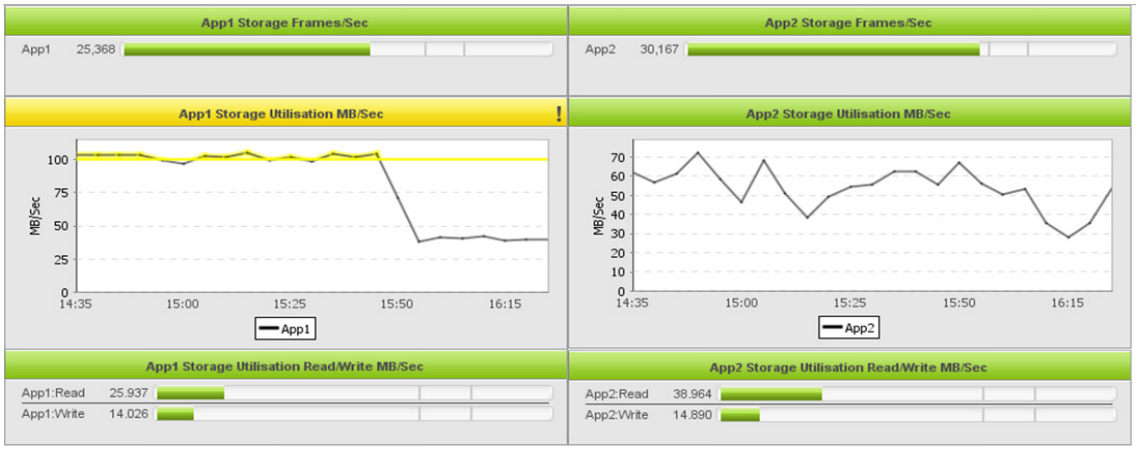
The lack of ability to actively measure SANs means storage architects design for the very worst case. In our engagements with customers, we have consistently found that storage networks at larger data centers are significantly over-provisioned, with average network link utilization rates of less than 5%. VirtualWisdom can help reclaim underutilized SAN ports to postpone acquiring additional expensive core switch ports, storage ports, related cables, and SFPs. Real time proactive monitoring, measurement, and alerting enables high consolidation rates without impacting performance as demands change. Changes in demand and performance can be detected long before users are impacted. Running reports that show latency and throughput per port enables the optimizations that balance utilization and increase consolidation.

In the VirtualWisdom dashboard widget at the right, you can see that the average utilization of most of these top storage ports is well below 10%, suggesting that there is a huge opportunity to consolidate links when new servers or applications are provisioned.



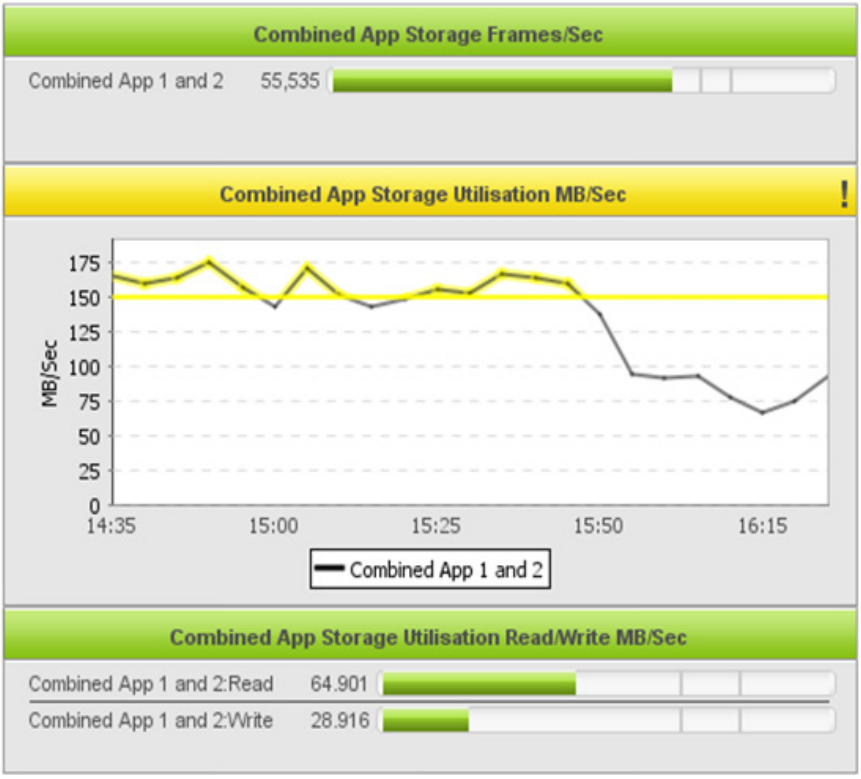
VirtualWisdom dashboard – top storage ports

Additionally, it is nearly impossible to hold all SAN variables constant in an effort to identify how configuration changes affect performance. It is difficult to plan and deploy datacenter consolidation due to a lack of meaningful data unless your analysis tools offer a simple way to measure using "what if" scenarios with actual production data. In the example below, VirtualWisdom shows the potential MB/s effect of a consolidation (what-if) using actual production I/O data.



Above, two applications using two different sets of storage ports

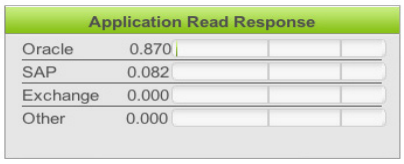
Below, combined metrics on storage ports for a merger of those two applications



VirtualWisdom dashboard showing "what if" analysis

Finally, a properly instrumented SAN offers real-time guidance. IT staff can baseline the performance before any SAN configuration change and measure after the changes, including queue depths, zoning, LUN mapping, and VSAN modifications.

Response times are base-lined then measured in real-time after consolidation has occurred.



"Before" and "after" VirtualWisdom dashboard widgets, showing effects of a configuration change

Private Cloud Best Practice

When you look at where people historically focus on system management, it's around capacity and utilization. Server and storage virtualization now make capacity planning relatively easy, shifting the key criteria for success in Cloud Computing to ***performance***. When you look at a virtualized or private cloud environment, optimizing CPU and memory only gets you so far. For I/O-intensive applications such as those running OLTP databases, looking only at server-related metrics is simply inadequate. I/O optimization is the key as it is the third leg of the "systems optimization stool".

Virtual Instruments' VirtualWisdom solution assesses the entire virtual infrastructure, not just pieces. It provides IT with the data necessary to make intelligent decisions about performance for every layer of the infrastructure, from the server to the storage. What administrators need is a way to see into multiple dimensions of the infrastructure, in real or at least near real-time. They need solutions that deliver the integrated monitoring and analytics required to optimize or troubleshoot private cloud infrastructure performance in real time, and across every involved system. As industry analyst Bernd Herzog recently noted, real-time performance-based analytics, inherent in the Virtual Instruments' VirtualWisdom solution, is the required foundation for building and managing a virtual private cloud infrastructure.

In the VirtualWisdom dashboard widgets below, metrics obtained from the server shows no latency problems. The same servers, with data obtained via VirtualWisdom's hardware probe, clearly shows a problem, allowing the server and storage administrators to see effect of the SAN infrastructure on application performance.

I/O metrics data from the server, at left, shows write latencies in the 20 ms range.

I/O metrics data from VirtualWisdom at right, shows write latencies from those same servers in the 40 ms range, not adequate for most OLTP applications.

VirtualWisdom's hardware monitoring is non-intrusive to the link and to the cloud component. It sees evidence of degraded behavior because it sees and measures everything, not just the upper layers of the stack, and not just what a cloud component tells it. It has a virtually unlimited ability to record and play back transactions. Hardware monitoring is like a CAT scan or MRI, only continuous and in real-time.

"As more people consider deploying mission-critical applications in a virtualized environment or look into deploying private clouds, it will be imperative for them to have complete real-time visibility into the response times of their virtual and physical IT infrastructure. Without the visibility enabled by solutions such as VirtualWisdom, they will be flying blind, exposing themselves to needless risk and wasted IT resources."

Bernd Harzog
The Virtualization Practice
June 2010

Summary and next steps

The benefits of consolidation are well understood and Virtual Instruments can help by providing best practices around storage and storage networking with an advanced measuring, monitoring, analysis, and optimization solution.

Real-time proactive monitoring, measurement, correlation, and alerting enables high consolidation rates without impacting performance as demands change. It enables a true SLA, and changes in demand and performance can be detected long before users are impacted. With VirtualWisdom's "what if" capabilities, IT staff can provide extremely accurate forecasts by using actual historical data and applying configuration changes to that data. Running reports that show latency and throughput enable the comparison and recommendation of other storage options that balance utilization and result in faster and less risky consolidation.

We hope you found this paper helpful, and we encourage you to talk with one of our Solutions Architects about your consolidation efforts.

Additional information:

Gartner Webinar
De-risking Applications in your Virtualized Infrastructure
July 2011

APM Experts White paper
Infrastructure Performance Management for Virtualized Systems
March 2011

Virtual Instruments Webinar
Reduce Storage Migration Risks - Best Practices for Private Cloud Migration
April 2011

IT Brand Pulse White Paper
Virtual Instruments: Early Incumbents in the VIO Market
August 19, 2010

Storage Switzerland White Paper
Optimizing Storage I/O Latency to Maximize VMware Performance
July 2010

Taneja Group White Paper
Building the Data Center for Infrastructure Visibility
April 2010

Storage Switzerland White Paper
Maximizing Tiered Stored ROI: Performance-Based Storage Tiering
April 2010

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