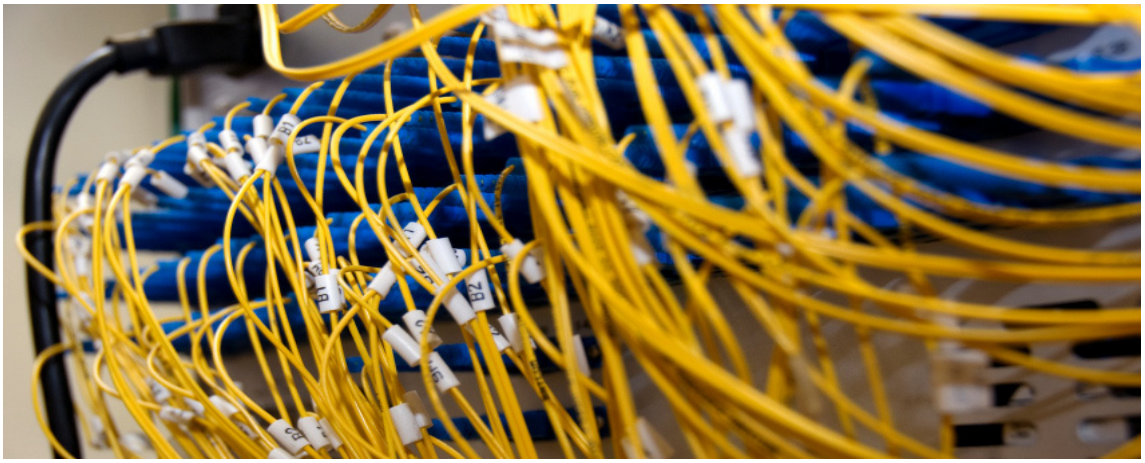
Technology Brief

VIRTUAL INSTRUMENTS



Best Practices for keeping application data flowing error-free – while transitioning to 8Gb

The continuing expansion of data centers and the introduction of new technologies such as server and fabric virtualization are driving the need for higher storage networking performance and greater capabilities from the data center fabric. Steady increases in performance and functionality have been the hallmark of Fibre Channel evolution over the past 15 years. With the periodic doubling of transport speed from 1 to 2 Gbit/sec, from 2 to 4 Gbit/sec, and to 8 Gbit/sec, storage administrators have exploited the new performance capabilities and advanced features to build more optimized storage networks.

This paper:

1. Discusses some of the considerations around 8Gbit/sec deployments
2. Offers best practices for ensuring a smooth transition
3. Suggests a case for extending the life of existing 2G and 4G fabrics

8Gbps CONSIDERATIONS

8Gbps Challenges for Architects

The increase in data transfer rates is potentially beneficial from a performance perspective. However, transitioning to higher speeds creates some real challenges for architects. In particular, the potential for increased data communication error rates that may result in disruption or performance degradation of business 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 8G can be realized in today's Storage Area Network (SAN) infrastructures.

As the data rate increases, sensitivity of induced jitter increases

As the speed of Fibre Channel bit rates increase from 1G (1.0625 Gbps) to 2G (2.125 Gbps) to 4G (4.25 Gbps), and to 8G (8.5 Gbps), the "window" for valid data (called a *bit period*) decreases proportionally to the speed. As shown in table 1, the bit period for FC at a 1G data rate is 941 picoseconds, whereas it falls to 235 picoseconds at 4G and only 118 picoseconds at 8G.

SUMMARY

- **8Gbps Transition** Fibre Channel is the storage fabric of choice for speed and reliability reasons. As such, most enterprises are taking a slow, phased approach to 8Gbps adoption. As with the transition to 4Gbps, the SAN vendors expect a gradual, multi-year transition to full deployment of end-to-end 8Gbps FC SANs.
- **8Gbps Best Practices** With higher speeds, it's more imperative than ever to ensure clean physical connections, and to instrument and measure your infrastructure.
- **Extending the Life of Existing Infrastructure** Existing 2Gb/4Gb enterprise FC SANs are nearly always vastly underutilized. This is a classic example of how you can do more with less via better utilization of existing SAN assets. Adding Virtual Instruments monitoring, measurement, and analysis solutions to your existing

Table 1: Bit Period at FC Data Rates

Fibre Channel Data Rates (Gbps)	Bit Period (picoseconds)
1G	941
2G	471
4G	235
8G	118

This reduction of the window requires a more robust infrastructure. Otherwise, the cabling and communications infrastructure may induce errors into the bit stream, leading to increased bit-error rates and costly transmission faults, causing retries or other performance-damaging consequences, and potential application disruptions.

When switching from 4G to 8G infrastructures, even well-performing 4G environments might quickly encounter unexpected failures running at 8G.

Jitter, which exists in varying degrees in all optical infrastructures, can result from any component within the infrastructure, including the quality of the optical transceivers, length and quality of fiber optic cables, quantity of in-line connectors, bend radius of the cables, and even the cleanliness of the cable junctions. For example: a small speck of dirt on the face of the optical cable junction, transparent at lower speeds, becomes a major error-inducer at higher speeds, slowing down critical applications.

Implications on the SAN infrastructure

Even if the network performed flawlessly at 4G, that does not guarantee the same result at 8G. As described above, an infrastructure running at higher speeds has a much higher sensitivity to induced jitter from dirty connections, excessive cable bend, poor quality SFP's, and other issues inherent to the infrastructure itself. **A light budget and error-analysis exercise is a best practice to test and ensure the existing infrastructure can support the new data rates. In some cases, new fiber optic cabling may be necessary to remedy any faulty infrastructure.**

Furthermore, once an infrastructure has been equipped to operate at the new higher speed, it may not remain error-free over a period of time. New cable installations, the addition of patch panels, or even slight adjustments made with existing cable routings can significantly increase jitter and reduce overall link performance. Extreme care must be taken to ensure links are as clean as possible, cables are not bent too much, and cable length and the number of connections are within the budget, preventing any foreign particles from deflecting light or excessive light loss as the light traverses the network.

Unfortunately, when these transmission errors are present (but while their true root cause remains unknown), network administrators often rely on "rip-and-replace" tactics in the hope that this will remove the offending component. Or worse, the root cause is assumed to be other SAN elements like host bus adapters (HBAs), and these are replaced unnecessarily. Not only is this expensive and extremely disruptive to the data center and to the critical applications, it often does not remedy the problem. The problem may disappear temporarily, providing a false sense of security, only to re-surface again without warning or apparent cause. This leads to endless fire-fighting and wasted time that could be applied to higher-value activities.

8Gbps TRANSITION – BEST PRACTICES

To ensure a smooth transition to higher speed infrastructures, network administrators should follow these best practices:

2Gb/4Gb corporate SANs dramatically improves data center ROI, eliminates expensive SAN infrastructure upgrades, lowers operational risk, and provides the flexibility to build out a large mission-critical application or cloud computing environment as needed, without the risk and expense of an 8Gbps fabric.

- **8Gbps VI Support** Virtual Instruments offers assistance and risk mitigation protection through availability of our 8Gbps ready TAPs, probe, optics /cables, protocol analyzer, and professional services consulting.

Physical Preparation

Clean the optical modules, connectors and the cable junctions. Ensuring there is no contamination in the fiber optic connections is very critical for the proper operation of the infrastructure. Optics-grade solvents, cleaning sticks and lint-free swabs are available from many different manufacturers that are engineered specifically for removing microscopic particles and trace oils from optics.

Instrument

Having all of the relevant information to optimize performance and solve virtual infrastructure and SAN-related problems requires capturing both directions of every SCSI I/O transaction from start to finish, for every server/volume combination (initiator/target/LUN). Only with this complete information can an IT organization go about resolving performance or availability problems.

In order to capture all of the SCSI transactions without impacting performance or reliability, the Fibre Channel SAN should be fully instrumented at every link that would carry business-critical data. As a key part of the Virtual Instruments solution, the Traffic Access Point (TAP) is the device that enables full instrumentation of the Fibre Channel network. It "taps" the network.

The Virtual Instruments TAP is a passive, non-performance impacting device that operates "out-of-band" and requires no power source or cooling. The TAP generates a copy of all data that is traversing the SAN by utilizing a small portion of the light within the fibre-optic cable and sends it to the Virtual Instruments SAN Performance Probe device for further processing.

With TAPs installed on all key links within the data center, users can deploy a number of devices that monitor and diagnose link performance without any further interruption or downtime. These devices, which include light meters and protocol analyzers, are engineered to detect a number of issues such as light levels, signal quality, throughput metrics, latency and response times, and protocol violations. These metrics provide a good indication of the health of the infrastructure and identify failing devices or bad links – all in real-time and at full line speed. An instrumented infrastructure takes the guesswork out of understanding optical link health, providing accurate visibility into the infrastructure operation.

With TAPs, an optical power budget analysis can be performed between transmit and receive ports. Make sure that the power margin (transmit power – power loss due to the length of the cable and the connectors between the two ports) is above the required receive power of the optical transceivers and meets the FC protocol specification.

Measure the light levels on the transmit side and receive side. Using light testers or light meters, measure the optical power levels on critical links and make appropriate adjustments to the length of the cables or bend radii of the cables. In some cases better quality optical transceivers or cables may be necessary to meet the power margin requirements.

This real-time visibility into infrastructure is extremely important as data rates increase from 2G and 4G to 8G rates. TAPs empower the SAN to provide uninterrupted access to business critical application data.

EXTENDING THE LIFE OF 2G AND 4G FABRICS

Overview

In most corporate data centers, 2Gb and 4Gb Fibre Channel Storage Area Networks (SANs) links are over-provisioned by a factor of 5x or more, on average. This is due to a lack of visibility into actual SAN performance and utilization data, which has led to massive hardware link over-provisioning in an attempt to avoid performance issues, to maximize availability, and to simply avoid risk. Traditional SAN management tools usually report on IOPS, a very poor indicator of network utilization. The emergence of VMware virtualization technology, making server resources flexible and applications readily mobile, adds another layer of abstraction and makes SAN visibility even worse.

While it's generally accepted that SAN **storage** utilization is low, only a few industry luminaries, such as John Toigo, have talked about the severe underutilization of Fibre Channel (FC) SAN **fabrics**.

The challenge of course, is that few IT shops have actually instrumented their SANs to enable accurate measurements of fabric utilization. Instead, 100% of enterprise applications get the bandwidth that perhaps only 5% of the applications need. "Better to be safe than sorry" is the oft-repeated mantra. But with SAN sizes rising at a 30 – 50% / year rate, many CFOs are starting to examine more than just the costs of servers and disks. They're looking at the entire infrastructure.

Over the past year and a half, Virtual Instruments has instrumented a significant number of global enterprise datacenters and for the first time, we remove the guesswork and present our report on FC SAN fabric utilization. Following is a chart that shows 2Gb/4Gb SAN utilization rates for some representative large enterprise SANs, before they undertook optimization projects with Virtual Instruments. Virtual Instruments has profiled dozens of large Global 1000 enterprise customers and the results are remarkably consistent – average utilization rates well below 10%.

Customer	Average FC Storage Port Utilization Rate
Large European Bank	3.0%
US Investment Bank	1.1%
US Energy Company	4.87%
International Consumer Products Company	8.6%

Beyond the obvious unnecessary expense the reality is, with such low utilization rates, simply building in more SAN hardware (HBAs, switches, cables, SFPs, storage ports) to address performance and availability challenges does nothing more than add complexity and increase risk. The more components that are deployed, the higher the probability of a failure. Most organizations' data stores are growing 30 - 50% per year, which means SAN infrastructures are growing at a similar rate. With compliance regulations such as HIPAA, Sarbanes-Oxley, BASEL II and others requiring corporations to keep increasing amounts of data longer, the demands on your storage infrastructure are only compounding. Though it's common to look at storage space itself as the place to reduce costs, especially with deduplication technology, the "network" in "SAN" can contribute to costs as well. It's not unusual for a storage port, after cabling, etc. to cost between $4K and $5K USD. It's no longer financially practical to overprovision SAN infrastructure. Most SANs are designed with redundancy, so over provisioning is really doubly expensive.

On the server side, IT is investing in server virtualization to consolidate servers and reduce capital and operating expenses. The same can be true for the SAN: virtualization and consolidation of underutilized SAN assets can easily save Global 1000 companies millions of dollars per year.

Optimized 2Gb/4Gb SAN Infrastructure can support future requirements

According to the statistics we've gathered from measuring Global 1000 corporate SANs, existing 2Gb and 4Gb SAN infrastructure can easily support more applications or a virtualized infrastructure, including private cloud computing environments. Balanced optimization of all SAN I/O transactions between servers and LUNs can enable support for a significantly greater number of servers and storage arrays with existing network infrastructures.

Increasing utilization of existing SAN infrastructure via intelligent load balancing would extend the return on investment (ROI), reduce complexity and risk, and help avoid both the potential headaches and excessive cost of implementing newer SAN hardware technology. For instance, many companies have found that they have to replace their physical infrastructure (patches and cables) in order to use 8Gb environments. When purchasing 8Gbg SFPs, you will need to either manually set each port to 4Gb, or ensure that your infrastructure is 8Gb-ready. Doubling or even a tripling of average utilization rates of 2Gb/4GB fabrics is now possible with the proper use of real-time monitoring and measurement solutions.

Unnecessary capital and operating expense can be avoided with optimization of your existing SAN infrastructure. Capital expense savings would result from the delay or complete avoidance of the acquisition of additional SAN switches, related software licenses, additional cables, and new racks –

potentially from the delay of building out and an entire new data center.

Operating expense savings would come from the delay or avoidance of costs related to implementation, configuration, testing, and documentation of new SAN infrastructure. Other operating expenses avoided include annual maintenance fees, management software licenses, power consumption, and cooling and floor space.

Optimization and troubleshooting of corporate SAN infrastructure is difficult, as existing management tools only give device-specific information. None of these tools provide a single view for all I/O transactions. If you're not able to measure all of the transaction data between servers and the LUNs, it is very difficult to understand what issues are causing problems and how to fix them.

The Solution: Virtual Instruments' VirtualWisdom

Virtual Instruments VirtualWisdom enables IT to optimize existing 2Gb/4Gb SAN infrastructure so it can provide consistent performance and reliability to support virtualized applications and internal cloud computing operations. VirtualWisdom is the only product that can monitor and send alerts about storage access times, congestion, link errors, and SCSI errors, and generate trend reports that show the behavior of a heterogeneous SAN, over time. This information helps to expedite troubleshooting and allows IT administrators to prove whether the problem is in the SAN or elsewhere, such as applications, hosts, or VMware VM's.

Summary

Existing 2Gb/4Gb enterprise FC SANs are nearly always vastly underutilized. This is a classic example of how you can do more with less via better utilization of existing SAN assets. Adding Virtual Instruments monitoring, measurement, and analysis solutions to your existing 2Gb/4Gb corporate SANs dramatically improves data center ROI, eliminates expensive SAN infrastructure upgrades, lowers operational risk, and provides the flexibility to build out a large mission-critical application or cloud computing environment as needed.

Transitioning the storage infrastructure to higher data rates has many benefits. However, it is paramount to understand the hidden pitfalls that may impact application performance and availability.

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