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SOLUTION BRIEF

Brocade IO Insight

HIGHLIGHTS

- Monitors individual host and storage devices to gain deeper insight into the performance of the network to maintain SLA compliance
- Obtains total IOs, first response time, IO latency (Exchange Completion Time, or ECT), and outstanding IOs performance metrics for a specific host or storage device, in order to diagnose IO operational issues
- Enables tuning of device configurations with integrated IO metrics, to optimize storage performance

IO Insight – Critical Visibility for Operational Stability

The Brocade® Gen 6 Fibre Channel network supports mission-critical applications with cutting-edge technologies for data center IT infrastructure that offer unparalleled bandwidth, scale, performance, and availability. Beyond these traditional requirements, the need for network visibility and actionable insight that IT administrators can use to ensure operational consistency and stability remain essential. Brocade Gen 6 technology continues to deliver innovation in this critical area, with the Brocade IO Insight capability. IO Insight complements and extends existing Brocade Fabric Vision™ technology and features with deep visibility on storage Input/Output (IO) performance to ensure operational stability. This solution brief presents the demand for IO Insight capability, explains the IO Insight metrics, and demonstrates the use cases for IO Insight. Finally, it compares and contrasts IO Insight with the Brocade Analytics Monitoring Platform.

The Challenge of IO Performance Monitoring

IT organizations continue increasing mission-critical workloads in their data centers. The demand for a large-scale storage network with optimal performance that is delivered consistently and with operational stability has increased dramatically. Data center customers need deep visibility into the performance of storage IO workloads to guarantee application performance between hosts and storage devices. At a very basic level, almost all customers need throughput-related performance metrics for each switch port to monitor utilization and prevent congestion. Beyond that, they need initiator-target flow level performance metrics to monitor performance associated with applications.

While Brocade Fabric Vision technology with Gen 5 products has addressed some of these requirements through the Brocade Monitoring and Alerts Policy Suite (MAPS) and Brocade Flow Vision diagnostic tools, visibility into additional key metrics can further ease administrative overhead and extend storage fabric resiliency to new levels. Specifically, administrators need latency and performance metrics for storage

IO operations that run on top of the storage network. These storage IO operations are Small Computer System Interface (SCSI) commands on a Fibre Channel (FC) network. Without this visibility, it is difficult to proactively monitor conditions to ensure consistent storage performance for applications.

For example, almost all large enterprise IT organizations have adopted solid state drive technologies, including either all flash arrays or hybrid flash arrays, which can dramatically reduce IO latency. These organizations tend to deploy their latency-sensitive applications to these devices. Yet, due to the lack of latency metrics, it remains a challenge to proactively monitor the performance of key infrastructure equipment to maximize Return on Investment (ROI). Furthermore, when performance problems related to storage IO operations occur, it is difficult for administrators to isolate the problem scope, in order to quickly troubleshoot the issues. These difficulties can result in suboptimal or unstable application performance and increased operational costs.

Brocade IO Insight

IO Insight is a Brocade Gen 6 Application-Specific Integrated Circuit (ASIC) built-in capability that nondisruptively and noninvasively gathers IO statistics. The instrumentation allows monitoring and baseline application-level and device-level latency and IOs per Second (IOPS) metrics to detect degraded storage performance. Administrators can proactively control performance and availability to ensure operational stability. IO Insight provides these metrics from device ports on Gen 6 platforms. To understand why these metrics are important, consider how Fibre Channel protocol structure supports the workloads in a storage network.

Fibre Channel protocol supports block storage. The majority of traffic running over Fibre Channel networks is SCSI IOs between server applications and storage arrays connected via a fabric. The SCSI protocol commands and data are mapped to FC protocol structures. A SCSI Read or Write operation between an initiator and target are divided into different phases. Each phase of the operation is mapped to a specific FC sequence. Depending on the IO data size, a sequence is mapped to one or more FC frames. The collection of frames and sequences that are associated with a single SCSI operation forms an FC exchange (see Figure 1).

A SCSI Read operation has three different phases: Command, Data, and Status as shown in Figure 2. A SCSI Write operation has four different phases: Command, Transfer Ready, Data, and Status as shown in Figure 3 on the following page. Each Command, Transfer Ready, and Status phase is represented by a unique FC sequence. Depending on the data size and on end-device implementation, the Data phase can be a single sequence consisting of multiple frames or multiple sequences, each consisting of multiple frames.

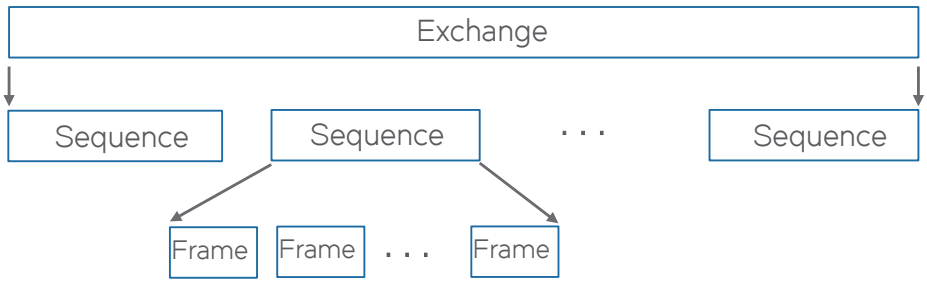

Figure 1: FC exchange, sequence, and frame.

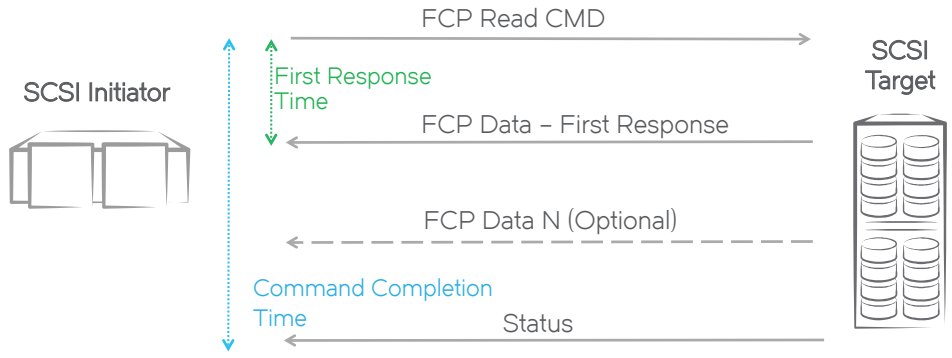

Figure 2: SCSI Read command (CMD) sequence and latency.

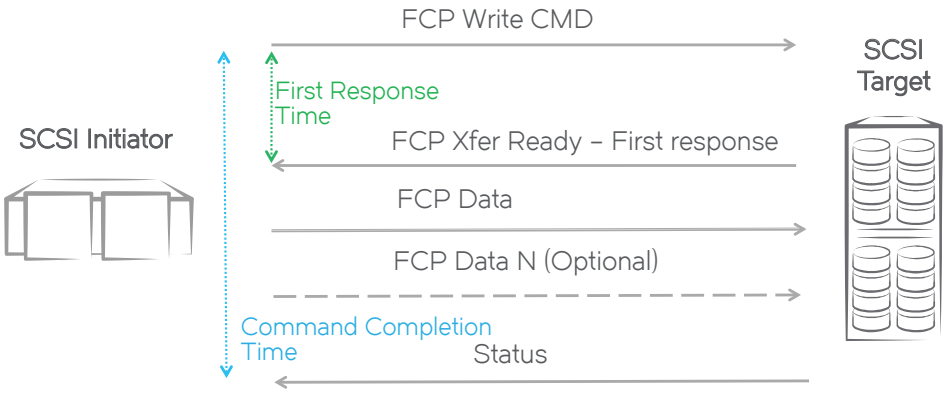

Figure 3: SCSI Write command sequence and latency.

Because of this multilayer protocol structure that carries the application storage traffic across a network, it is important to have visibility at the different layers. Certain metrics can be obtained only at a particular layer. The FC frame layer metrics provide throughput and frame rate information that represents the speed at which frames are processed at a port. Frequently, these metrics might not provide sufficient visibility on the health of storage IO operations. For example, while the frame level throughput for an initiator-target flow is normal, the application response may still be slow due to many IO operations that are handled by the storage target and Logical Unit Number (LUN). Metrics for IO latency and IOPS can only be obtained at an FC exchange layer, since each exchange represents a specific SCSI Read or Write operation. Although server-side or array-side tools exist to provide this information outside of a fabric, without the visibility from a fabric, Storage Area Network (SAN) administrators face the complexity of Service-Level Agreement (SLA) compliance for multiple applications running in a fabric. When issues related to application IO performance and reliability occur, it is difficult to pinpoint the source of the problem without the metrics from the perspective of a fabric. As a result, a fabric is usually assumed to be the cause of the problem.

Defining IO Insight Metrics

IO Insight metrics are provided on Gen 6 device ports, that is, ports connected to hosts or targets. The metrics are not available on Inter-Switch Link (ISL) ports, because it is commonly sufficient to obtain device-level IO metrics on the edge ports in a fabric. It is important to note that IO Insight metrics are always measured from the perspective of device ports. In other words, the metrics represent the timing when a frame enters or leaves a switch port. Normally, the metrics may differ slightly from what the host or target side IO performance tools report. IO Insight includes the following metrics.

First Response Time: The First Response Time measures the time between when a SCSI command frame is issued by an initiator and the first response frame is issued by a target. For a Read command, the first response is the first data frame sent by the target (see Figure 2). IO Insight displays this metric as "RD CMD -> 1st Data Time." For a Write command, the first response is the Transfer Ready (Xfer_ready) frame responded by the target (see Figure 3). IO Insight displays the metric as "WR CMD -> 1st XFER_RDY Time." The First Response Time indicates the access time delay for a Read or Write operation. When a First Response Time is obtained at a host port, it includes fabric latencies and target device latencies. When a First Response Latency Time is measured at a target port, it measures only target device latencies.

Command Completion Time: The Command Completion Time, also commonly known as the Exchange Completion Time, measures the time between when a SCSI command is issued by an initiator and when the status frame is issued by a target to indicate the completion of that operation. For a Read command, IO Insight displays the metric as "RD CMD -> Status Time" (see Figure 2). For a Write command, IO Insight displays the metric as "WR CMD -> Status Time" (see Figure 3). The Command Completion Time indicates the total time delay, including access time and data transfer time, for a Read or Write operation. When a Command Completion Time is obtained at a host port, it includes fabric latencies and target device latencies. When a Command Completion Time metric is obtained at a target port, it measures only target device latencies.

The First Response Time and Command Completion Time are usually the best indications of application performance impact, because persistently high values typically result in slow application responsiveness and poor user experience. For any mission-critical application, this condition often requires immediate resolution by SAN administrators.

Pending IO: The number of Pending IOs measures the average number of IO operations that are pending completion when a Read or Write command is issued by an initiator, that is, the number of IO operations that are outstanding between the Command phase and Status phase. The metrics are provided separately for pending Read commands and for pending Write commands. IO Insight displays the average pending Read commands as "RD Pending IO." It displays the average pending Write commands as "WR Pending IO." The Pending IO metric is closely associated with queue depth, which is the maximum number of Pending IOs for a server or a storage. Server Host Bus Adapters (HBAs) typically support queue depth configuration to control IO operations to run concurrently on servers. Storage arrays usually have a maximum queue depth limit that it can support from all servers.

IO Count: The total number of completed SCSI IOs between a pair of initiators and targets. IOPS means the average rate of completed SCSI IOs per second. IOPS a commonly used metric to baseline the performance of storage systems. IO Insight provides separate metrics for completed Read commands and for completed Write commands. IO Insight displays the completed SCSI Read metric as "RD IO Count" and the completed SCSI Write metric as "WR IO Count." Storage arrays typically include IOPS specifications. The IOPS metrics with IO Insight provide validation and monitoring of storage array performance in production environments.

The SCSI IO performance and latency metrics are inherently affected by the data size of the IO commands. Typically, IOs with large data size take longer to complete, resulting in higher command completion time and lower IOPS. On the other hand, IOs with a small data size require shorter times to complete, resulting in lower command completion time and higher IOPS. These characteristics require metrics of different IO sizes to be provided. Hence, IO Insight provides each of the above metrics for four different ranges of data size: less than 8 Kilobytes (KB), 8 KB or above but less than 64 KB, 64 KB or above but less than 512 KB, and 512 KB or above. The metrics based on data sizes provide the necessary information to understand the IO workload profile, in order to establish baseline behavior for accurate monitoring.

The Accuracy of IO Insight Metrics

In order for IO Insight to be useful for measuring performance at high speed and low latency, the metrics that are gathered must be accurate. In the following example, a host generates 8,192 IOs to a target, each with 2,000 bytes of data. The metrics for this flow are obtained by IO Insight and by the JDSU Xgig Fibre Channel Analyzer. Table 1 compares the metrics for these two methods.

IO Insight with Flow Vision and MAPS

IO Insight capabilities are integrated into the existing features of Brocade Fabric

Table 1: IO Insight metrics compared with the JDSU Fibre Channel Analyzer.

	Metrics	IO Insight	Xgig Expert Report
	READ IO Count	8.19 K	8,192
	WRITE IO Count	8.19 K	8,192
Maximum	RD CMD -> Status Time (microseconds)	69	68
	WR CMD -> Status Time (microseconds)	89	88
	RD CMD -> 1st Data Time (microseconds)	54	53
	WR CMD -> 1st XFER_RDY Time (microseconds)	66	65
	RD Pending IOs	4	4
	WR Pending IOs	4	4
Average	RD CMD -> Status Time (microseconds)	39	38
	WR CMD -> Status Time (microseconds)	47	47
	RD CMD -> 1st Data Time (microseconds)	23	23
	WR CMD -> 1st XFER_RDY Time (microseconds)	19	19
	RD Pending IOs	2	N/A
	WR Pending IOs	2	N/A

Vision technology. The IO Insight metrics are accessible through Flow Vision. Users define initiator-target or initiator-target-LUN flows with the Flow Monitor function to obtain the IO Insight metrics. The average and maximum values of IO Insight metrics are sampled every six seconds to provide the current values. The average and maximum values across all sampling periods since the flow activation are maintained to provide history information. In addition, Brocade Network Advisor 14.0.1 supports the IO Insight metrics displayed in the Flow Vision real-time performance graph for the past six hours.

The screen capture in Figure 4 of the Brocade Network Advisor real-time performance graph displays the IO Insight metrics. Administrators can save this performance graph as a widget and add it to the Brocade Network Advisor dashboard for at-a-glance performance view of the important IO flows.

As described in the previous section, IO Insight metrics are available on device ports. Flow Vision requires a port parameter in the flow definition as the reference point of metrics. To obtain IO Insight metrics on an initiator port, the point of reference must be defined on the ingress port, whereas to obtain the metrics on a target port, the point of reference must be defined on the egress port. This initiator-target direction aligns with the SCSI Read and Write command directions. If a flow is defined with the direction reversed, IO Insight metrics are not available.

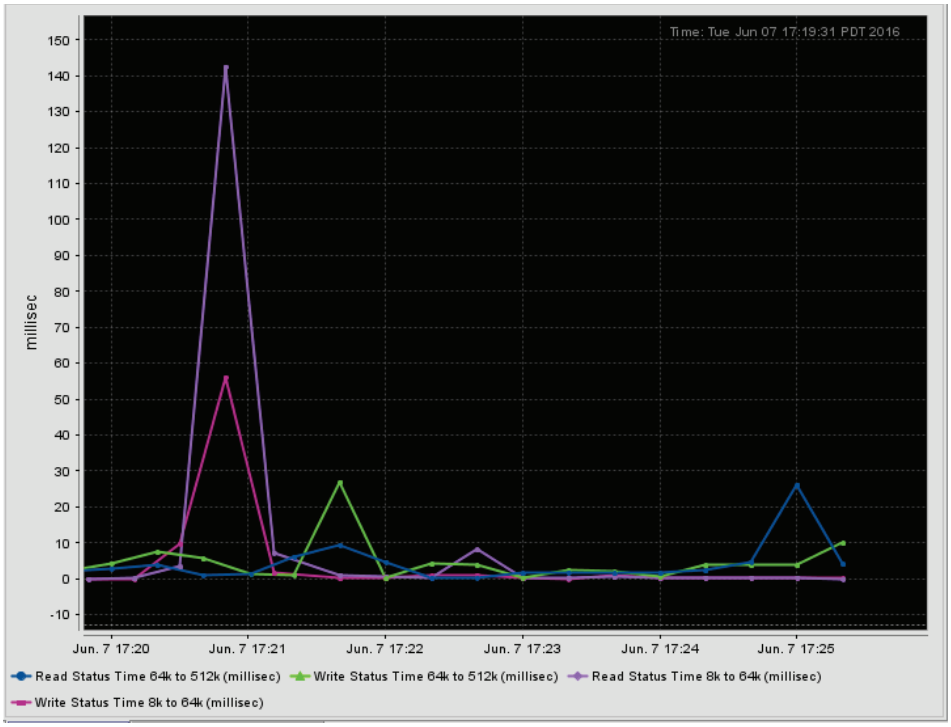

Figure 4: IO Insight metrics displayed in a Brocade Network Advisor real-time performance graph.

The IO Insight metrics available to Brocade Gen 6 fixed-port switches and Gen 6 directors are offered differently, in order to align with the different market segments that these products serve. The Gen 6 fixed-port switches can obtain IO Insight metrics only on the target device ports: only flows with egress port directions are supported. The Gen 6 directors can obtain IO Insight metrics on either host device ports or target device ports: flows with either ingress port or egress port directions are supported. Furthermore, Gen 6 fixed-port switches can obtain IO Insight metrics for initiator-target flows only. Gen 6 directors, on the other hand, support IO Insight metrics for initiator-target or initiator-target-LUN flows to be able to obtain LUN-level IO performance visibility.

After IO Insight metrics are available through a Flow Monitor flow, the flow can be imported into MAPS to configure threshold-based monitoring and alerting on the latency metrics. Users can configure maximum acceptable IO latencies for a particular Initiator-Target or Initiator-Target-LUN flow. Different thresholds for each of the data size ranges can be configured. The thresholds can also be configured over the time window of a minute, an hour, and a day, to support monitoring at different granularity. When latencies above the threshold are detected by MAPS, users receive MAPS notifications based on the preconfigured threshold actions and can then take appropriate measures to respond.

As mentioned, Brocade Network Advisor supports IO Insight metrics with Flow Monitor performance graphs. These performance graphs can be added to dashboards. Administrators can create a custom dashboard that includes a

widget with IO Insight metrics, in order to gain a quick at-a-glance view of the key performance statistics for important flows. In addition, other widgets from existing Brocade Fabric Vision technology features, such as MAPS dashboards and Fabric Performance Impact (FPI) monitoring violations, can be displayed in the same dashboard. Administrators can easily correlate the data from different tools.

IO Insight Use Cases

With IO Insight capabilities, the following use cases are supported:

Storage Performance SLA Compliance

When administrators are responsible to guarantee the performance and reliability of their storage networks, throughput and latency are sometimes the key parameters in the SLAs to their customers. The integrated capabilities of IO Insight are well suited for this use case. In an environment with mixed Hard Disk Drive (HDD) and Solid-State Drive (SSD) storage arrays that support mixed workloads, administrators may be required to guarantee the latency for IO operations to be under a certain threshold, for example, 25 milliseconds, to ensure the responsiveness of applications.

In order to achieve that requirement, users can create Flow Monitor flows with target devices (destination ID) specified but source devices (source ID) unspecified. This flow definition provides the IO Insight metrics for all flows that are destined to the specified target devices. The flows can be imported into MAPS and configured with Read and Write completion time thresholds of 25 milliseconds over the desired monitoring time window. If this baseline is violated, administrators are notified to take early action before their customers request support.

For certain specific latency-sensitive applications that may be provisioned with high-performance all flash arrays, a higher SLA might be mandated. In such an example, if the customer's latency tolerance is under 5 milliseconds, the administrator can set up a customer-specific threshold. Administrators can define a separate flow with fully specified initiator, target, and LUN IDs to monitor the storage target or LUN performance for the desired applications. All these monitoring steps can be accomplished through Brocade Fabric OS® (Brocade FOS) Flow Vision and MAPS commands, or through Brocade Network Advisor. The fact that this built-in capability can be enabled at any time and on any device port without any disruption makes this a very powerful, yet flexible, tool.

Storage Performance Troubleshooting

The second use case for IO Insight is troubleshooting storage performance problems—in particular, IO performance issues. When applications experience IO-related performance problems such as a slow response, a time-out, or even a crash, administrators are under pressure to resolve the issues quickly. Because many elements within a storage network can affect performance, it is often necessary to isolate the root cause of a problem to either within a fabric or to a storage device.

IO Insight is a valuable tool in this step. Flows can be defined on storage ports to obtain IO Insight metrics. Since these metrics are obtained on storage ports, they represent the performance and latency of storage devices. If these metrics are abnormal, it is very likely that the problems are due to the storage devices rather than to the fabric. On the other hand, if these metrics are within the normal range, the problem can be within the fabric or from the hosts.

With Gen 6 directors, administrators can further troubleshoot by defining a flow with the same initiator and target, but on the host ports. If the metrics fall within the normal range, then the problem is likely caused by a host side issue. On the other hand, if the metrics are abnormal, problems within the fabric or the slow draining host are likely causing the slow responses. Administrators can correlate the Fabric Performance Impact monitoring to confirm whether the host is a slow draining device. If the host is not a slow draining device, it is likely that the congestion within the fabric is affecting the performance of this flow. Once again, IO Insight provides the visibility for troubleshooting with a few commands or clicks, without any disruption to operations.

Storage Performance Optimization

The third use case for IO Insight is optimizing the performance of a storage network. For latency-sensitive applications, administrators can use IO Insight metrics to directly measure IO latency to any storage targets, so that they can make informed decisions to properly provision and deploy these applications. Furthermore, administrators can utilize the IO Insight metrics—in particular, the Pending IO metric—to tune and optimize the performance of the overall storage network.

As mentioned in the previous section, storage arrays have physical upper limits on the number of IOs that can be supported concurrently. This limit is known as queue depth. At the other end, server HBAs have queue depth settings that control the number of concurrent IOs on a LUN. HBAs and different

driver versions have default queue depth settings, which most likely are not optimized for a production environment.

To prevent exceeding a storage array's queue depth limit, it is important to know the Pending IO values for each initiator. These can be obtained by iterating through all initiator flows. Administrators can use this data in conjunction with the number of servers to a storage port, and with the number of LUNs to a storage port, to determine if the HBA queue depth settings should be lowered. In addition, the Pending IO metrics can be compared with the latency metrics to set a higher HBA queue depth for latency-sensitive mission-critical applications and a lower queue depth for less critical applications.

IO Insight and Brocade Analytics Monitoring Platform

Brocade Analytics Monitoring Platform (AMP) provides the advanced storage telemetry to enable unmatched monitoring, advanced troubleshooting, and increased ROI. IO Insight provides some of the capabilities that are offered in AMP. As available on AMP, the SCSI IO latency and performance metrics can also be obtained through IO Insight nondisruptively. But AMP has many advanced capabilities beyond what IO Insight offers, as follows.

- **Full automation:** AMP supports automatic learning of all Initiator-Target and Initiator-Target-LUN flows passing through a fabric switch that has enabled virtual tap (vTap). This means that administrators do not need to specify a source device, destination device, or LUN ID to gain visibility of the IO performance. This automatic learning capability can be critical in a large storage network that supports thousands of devices.
- **Deeper visibility:** AMP provides full visibility to all SCSI commands, beyond the SCSI Read and Write commands that are offered by IO Insight. In addition, because the metrics are obtained on the AMP device, AMP can directly measure and monitor the fabric latency if vTap is enabled on both host ports and target ports. This deeper level of visibility on AMP makes it a powerful tool to perform extensive diagnostics and troubleshooting.
- **High scalability:** As a dedicated storage analytics appliance, AMP is highly scalable: Its capabilities range from monitoring a few Gen 5 and Gen 6 platforms with hundreds of flows, to monitoring a large fabric with tens of thousands of flows. Both performance and latency thresholds are monitored, and violations can be alerted at time windows of a day, minutes, seconds, and down to each IO command.
- **Customized management interface:** Brocade Network Advisor supports deeper integration with AMP capability, offering a dedicated Analytics Monitoring dashboard with default widgets. Brocade Network Advisor supports deep AMP metrics retention for up to two years. In addition, the Brocade Network Advisor report generation capability dedicated for AMP provides crucial operational summary on demand.

With these key differentiations, AMP is recommended for end-to-end IO monitoring and advanced troubleshooting in environments with Gen 5 or Gen 6 switches, while IO Insight is recommended for storage performance monitoring with Gen 6 switches.

Summary

IO Insight is one of the key offerings of the Brocade Gen 6 Fibre Channel technology. Data center administrators can leverage this integrated capability to gain visibility on application IO performance to ensure SLA compliance, troubleshoot IO performance problems, and optimize the storage performance in their environment. This unique nondisruptive solution further advances the benefits of Brocade Fabric Vision technology by offering simplified management, increased operational stability, and reduced costs.

About Brocade

Brocade networking solutions help organizations achieve their critical business initiatives as they transition to a world where applications and information reside anywhere. Today, Brocade is extending its proven data center expertise across the entire network with open, virtual, and efficient solutions built for consolidation, virtualization, and cloud computing. Learn more at www.brocade.com.

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