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White Paper

Cyber Resilience with IBM TS7770 Grid and Brocade® 7850 Extension Switch

Cyber resilience and data availability are crucial to an organization's survival, especially when faced with an unexpected catastrophe. From finance and healthcare, to transportation and retail, to city, state, and federal government, organizations must adopt proven business continuity and recovery management strategies and storage technologies to successfully address operational risk, availability, and security challenges. One way to reach this goal is to plan and implement a resilient mainframe and extension solution that allows an organization to respond and adapt to various external and internal demands, disruptions, disturbances, and threats while continuing business operations without significant impact.

A key component in a resilient IBM Z architecture is the IBM TS7770 with its multi-cluster Grid configuration. The configuration is a series of clusters connected by a network to form a high-availability, resilient, virtual tape infrastructure. Logical volume attributes and data are replicated via IP across clusters joined by the Grid network. The Grid looks like a single storage subsystem to the host, ensuring high availability and production work continues even if an individual cluster becomes unavailable.

The Brocade® 7850 Extension Switch and Brocade SANnav™ Management Portal enable TS7770 Grid users to significantly increase performance, security, reliability, and availability between clusters. This paper details Brocade Extension technology's features and advantages to an IBM TS7770 Grid network.

Introduction: Cyber-Resilient IT Architectures

A cyber-resilient IT architecture allows an organization to respond to external and internal demands, disturbances, and threats while continuing operations without significant impact. While it is related to disaster recovery, implementing a cyber-resilient architecture requires organizations to go beyond planning for recovery from an unplanned outage. A cyber-resilient architecture enables organizations to avoid outages altogether.

In business continuity, the most expensive component is the WAN bandwidth between sites. The goal of an IBM TS7770 Grid network, referred to as Grid, architecture is to maximize resilience at the lowest cost. In other words, this architecture maximizes network efficiency by employing connectivity devices that offer the highest performance, highest availability, lowest operating cost, and are easy to manage. The Brocade 7850 is such a device.

With an IBM TS7770 Grid network connected to the Brocade 7850, an IBM Z customer can achieve a highly available, performance-optimized architecture with low operating costs. This architecture simplifies the management of the entire Grid network by using a single pane of glass provided by Brocade SANnav Management Portal and SANnav Global View.

This paper explains the basics of the IBM TS7770 Grid solution and describes the features and technology available from Broadcom that help to ensure an optimal Grid solution.

Challenges in Designing a Cyber-Resilient IT Architecture

An IT outage can generate a substantial adverse business impact, even if the outage lasts only a few minutes. The negative publicity that such an event can generate in today's connected world can have longer-lasting effects than the event itself.

Clients, partners, and the market in which a business operates drive the need for continuously available, resilient architectures. The potential revenue loss from an outage and the damage to a company's reputation is costly. Challenges from possible government sanctions in an increasingly complex regulatory environment can exacerbate these costs.

Companies across diverse industries face growing challenges when planning for cyber resilience. Executive focus on resilient architecture solutions, such as the IBM TS7770 Grid, is increasing because business leaders realize more is needed than just planning for disaster recovery. Enterprises that run IBM Z need greater availability to deal with various contingencies. These contingencies can be as simple as accidental power loss and common configuration errors, and as complex as natural disasters such as hurricanes and earthquakes, or human-induced disasters such as terrorism. A business that plans for a resilient architecture must implement both traditional disaster recovery and plan for continuous availability.

The IBM TS7770 Grid enhances IT infrastructure cyber resilience. As data stores grow, tape operations become complex. The IBM TS7770 solution is deployed in multiple networked, multi-site configurations for high availability and disaster recovery. A Grid is configured to eliminate downtime from planned and unplanned outages.

The network infrastructure supporting an IBM TS7770 Grid solution faces challenges and requirements. First, the network components must be reliable, have high-availability features, and work in a resilient architecture. The overall solution is only as good as its parts. A Grid network requires nonstop, predictable performance with the system having five nines availability, in other words, 99.999% uptime. Second, a Grid network must be designed with highly efficient components that minimize operating costs. Third, today's rapidly growing amounts of data require a network that meets these specifications:

- Uses highly scalable components that support business and data growth and application needs
- Helps accelerate the deployment of new technologies as they become available

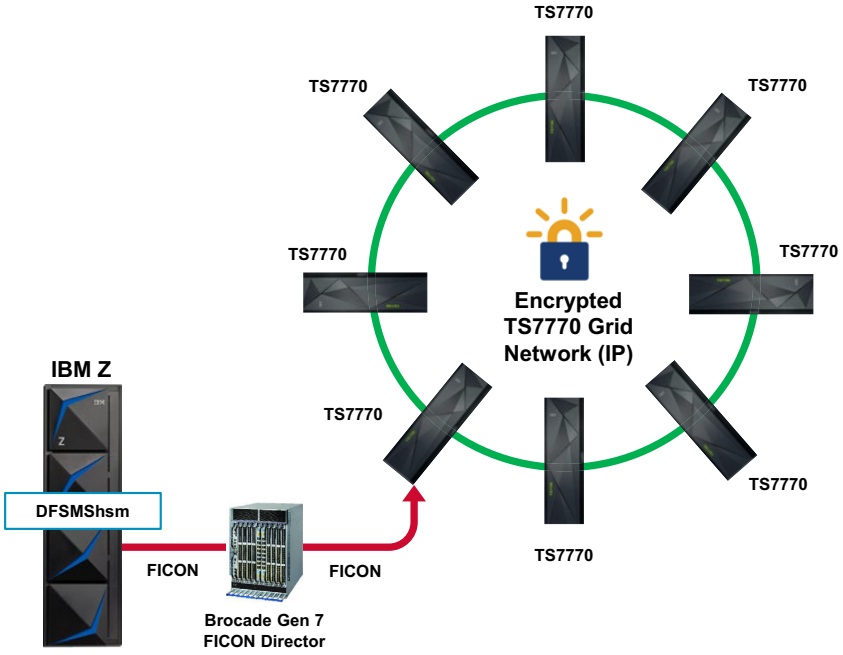
IBM TS7770 Grid Basics

A prior-generation technology produced the IBM Virtual Tape Server (VTS) and a feature called Peer-to-Peer (PtP) VTS, a multisite-capable business continuity and disaster recovery solution. PtP VTS was to tape, what Metro Mirror and Global Mirror, formerly PPRC, was to direct access storage devices (DASD). PtP VTS-to-VTS data transmission was done initially by ESCON, then by FICON, and now by TCP/IP.

The IBM TS7770 eliminated the virtual tape controllers and channel extenders needed for PtP VTS. This change provided the potential for a business continuity solution that simplified infrastructure and management. Hosts attach FICON directly to the IBM TS7770s, and the connections between clusters use TCP/IP. Like PtP VTS, the Grid transports replication data between clusters. Data is accessed from the Grid regardless of which cluster holds the data.

The TCP/IP infrastructure that connects IBM TS7770 clusters is called the Grid. As a high-availability cyber-resilient solution, multiple IBM TS7770 clusters are interconnected over the WAN, as shown in Figure 1. Local and geographically separated connections are supported to provide significant flexibility in addressing customer needs. A Grid may have two to eight physically separated clusters connected by a customer-supplied IP network. The Grid forms a high-availability disaster recovery solution that provides metro and remote logical volume replication. The clusters in an IBM TS7770 Grid can be geographically dispersed but do not need to be. In a multiple-cluster Grid configuration, two IBM TS7770 clusters are often located within 100 km of each other, and the remaining clusters are usually further away (1000 km or more). The solution is highly available and redundant. It also provides for remote disaster recovery outside the region.

Figure 1: IBM TS7770 Grid Topology Example



The IBM TS7770 Grid introduces flexibility for designing cyber-resilient solutions. Peer-to-peer communication is integrated into the architecture and design. The Virtual Tape Controllers (VTC) of the previous generations of PtP VTS are eliminated, and the interconnection interface is standards-based TCP/IP/Ethernet networking. If configured for high availability, host connectivity to multiple IBM TS7770s is required to maintain data access if one of the IBM TS7770s fails. If the IBM TS7770s are at different sites, Brocade Extension equipment is required to extend the host connections to a remote cluster.

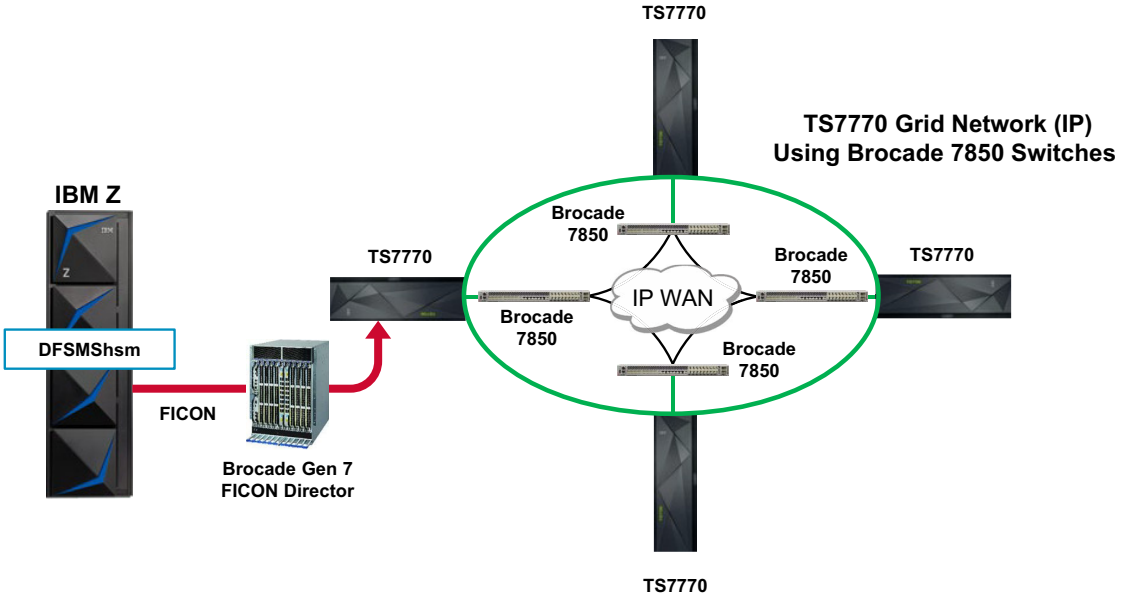
With the TS7770 Grid, data is replicated and stored in a remote location to support truly continuous uptime. The IBM TS7770 includes multiple modes of synchronous and asynchronous replication. Replication modes can be assigned to data volumes by using the IBM Data Facility Storage Management Subsystem (DFSMS) policy. This policy provides flexibility in implementing cyber-resilient solutions, so organizations can simplify their storage environments and optimize storage utilization. This functionality is similar to IBM Metro Mirror and Global Mirror with advanced copy services support for IBM Z.

The IBM TS7770 Grid is a robust business continuity and cyber-resilient solution. Organizations move beyond the inadequacies of local backup, disk-to-disk, or disk-to-tape, which cannot protect against regional natural disasters and human-induced malicious events. Using Grid, data can be replicated and accessed remotely beyond the circumference of catastrophe.

An organization can adapt quickly and dynamically to changing business environments with increased storage flexibility. Switching production between peer IBM TS7770 can be easily accomplished in a few seconds. IBM Z customers with a Grid solution can eliminate planned and unplanned downtime. This approach can save thousands of dollars in lost time and business while addressing today's stringent government and institutional data protection regulations.

A Grid network requires predictable nonstop performance with components having five nines availability. The Grid network must be designed with efficient and scalable components that minimize operating costs. Scalability supports business growth, data growth, application needs, and new technology deployments. The Brocade 7850 with Brocade SANnav Management Portal provides these benefits, removes distance impact, and transparently recovers from specific network outages. The Brocade 7850 Extension Switches interface to the IBM TS7770 10Gb/s Ethernet interfaces and manage the long-distance data delivery. Figure 2 provides a high-level view of where the Brocade 7850 fits within the architecture.

Figure 2: IBM TS7770 Grid Using Brocade 7850 Platforms: Topology Example

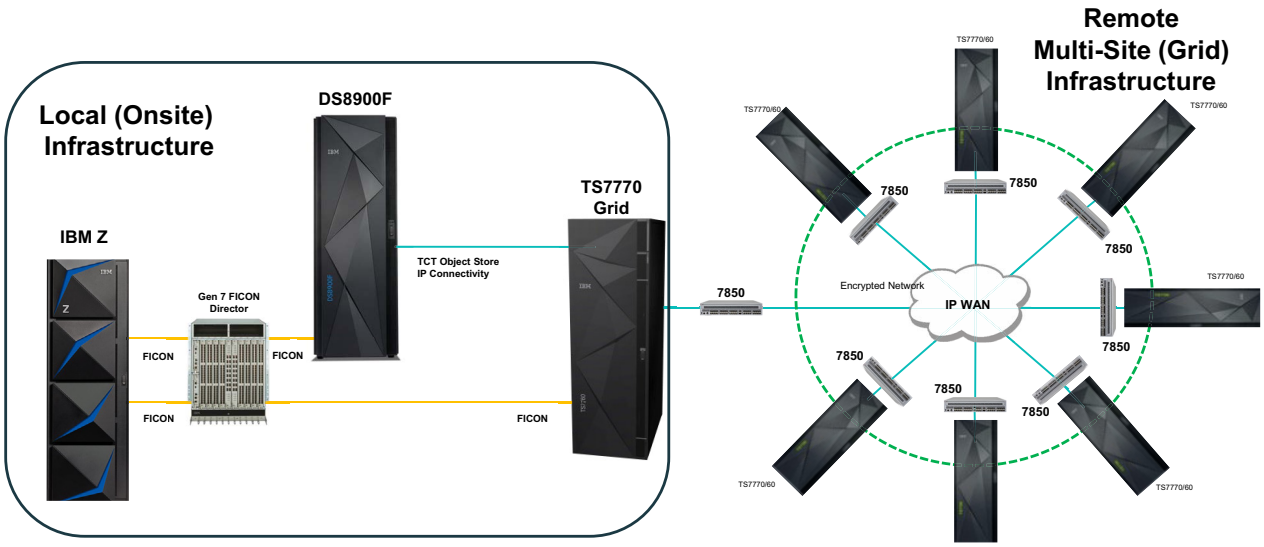


IBM Transparent Cloud Tiering and TS7770 Grid

Cloud resources are strategic to cyber resilience and high availability; IBM transparent cloud tiering (TCT) enables hybrid cloud storage architectures in an IBM Z environment. Organizations can introduce a hybrid cloud as a storage tier for data archiving, long-term retention, and protection. Without any performance impact, TCT offloads backup and archive operations from the mainframe to IBM DS8900 storage systems and IBM TS7770 virtual tape libraries (VTL), dramatically reducing mainframe CPU utilization and freeing resources for business-critical applications.

IBM TCT is a combined solution between the Mainframe DFSMShsm program, IBM DS8900F, and the IBM TS7770 Virtual Tape subsystem. TCT converts block storage on the DS8900F to object stores, which are moved to the locally attached TS7770 clusters. To protect the object stores, the IBM TS7700 Grid moves data to remote WAN-connected clusters. See Figure 3 for a high-level view of the TCT and Grid Solutions.

Figure 3: Transparent Cloud Tiering Architecture



Brocade 7850 Extension Switch Basics

The Brocade 7850 is a purpose-built extension solution. It is an enterprise-class product with an essential feature set: superior performance, strong security, high reliability, robust monitoring, flow visibility, and extensive diagnostic tools. The Brocade 7850 is an ideal platform for building a high-performance data center extension infrastructure for replication and backup solutions. It leverages inter-data center WAN transport to extend open systems and mainframe storage applications over any distance. With the use of Extension, those distances are possible and practical. In addition, the Brocade 7850 addresses the most demanding disaster recovery requirements. With twenty-four 64G FC/FICON ports, sixteen 1/10/25-GbE interfaces, and two 100-GbE interfaces, customers can achieve the bandwidth, port density, and throughput needed for maximum application performance over a wide area network (WAN).

Brocade Extension technology integrates perfectly into any IP network and provides a highly efficient data transport capable of full bandwidth utilization across great distances. The valuable features of Brocade Extension in an IBM TS7770 Grid environment include Extension Hot Code Load (eHCL), Brocade Extension Trunking, WAN-Optimized TCP (WO-TCP), encryption (IPsec), Adaptive Rate Limiting (ARL), and Brocade SANnav. Broadcom provides a full spectrum of security features and validation tools. Overall, Brocade Extension products leverage over 20 years of distance connectivity innovation and industry leadership, as demonstrated by its ranking as the market's preferred solution.

The Brocade 7850 can perform Fibre Channel and FICON over IP (FCIP) and IP Extension, making the Brocade 7850 an ideal platform for IBM TS7770 Grid connectivity. This section of the white paper discusses Brocade 7850 basics. The remainder of the white paper does not focus on Brocade 7850 FCIP capabilities; instead, it focuses on IP Extension specifics related to IBM TS7770 Grid replication.

Brocade 7850 Extension HCL

Extension Hot Code Load (eHCL) was introduced to the storage industry with the Brocade 7840 (Gen5). Firmware updates are done without tunnel disruption. A firmware update without eHCL stops a potentially extensive data replication. Years ago, WAN links had much less bandwidth, and it was not paramount to maintain connectivity during a firmware update. The journal of data was acceptably small. By today's standards, the amount of journaled data during a firmware upgrade may be significant, on the order of a terabyte or more. Nonstop IBM TS7770 Grid replication is required to meet recovery point objective (RPO), maintaining an acceptable comfort level. The Brocade 7850 is the only product on the market that preserves extension connectivity during a firmware upgrade. Brocade eHCL is lossless and keeps data in order when activated. During the firmware update process, no data is lost in flight and all data remains in order. eHCL can be used in mainframe environments without causing interface control checks (IFCC), a testament to the underlying technological advancement.

Security of IP Extension Flows: Encryption

Private WAN connections are not secure outside the data center. Unsecured data leaving the data center brings opportunities for data breaches and potentially unwanted publicity. Government regulation and internal audit requirements often drive data protection requirements; increasingly, storage administrators are required to encrypt data leaving the data center.

Broadcom has developed hardware-based encryption for secure data in flight across Brocade Extension. Brocade encryption operates at line rate and introduces only a few microseconds of added latency, making it useful for synchronous applications. Brocade encryption uses AES-GCM-256, Diffie-Hellman 2048-bit Modular Exponential (MODP), Internet Key Exchange version 2 (IKEv2), Hashed Message Authentication Mode Secure Hash Algorithm 512 (HMAC-SHA2-512), and Transport Mode, and it is rekeyed every few hours without disruption. A pre-shared key (PSK) is configured, or CA-signed certificates are installed.

The best practice with IBM TS7770 Grid is to use Brocade encryption. It protects data from nearly every attack, including eavesdropping, data modification, identity spoofing, man-in-the-middle, and denial of service (DoS). Brocade encryption requires no additional licenses or costs and is simple to configure. Encryption protects Brocade Extension Trunking and allows granular load balancing of encrypted flows across all circuits. 50Gb/s is a large amount of encrypted bandwidth, and up to 50Gb/s is supported per trunk per data processor (DP). There are two data processors on a Brocade 7850. Encryption prevents the need for costly and complex firewalling. Because firewalls are software-based, they tend to provide poor performance at rates near 50Gb/s.

Brocade encryption implementation performs better than the IBM TS7770's native encryption. The Brocade 7850 encourages encrypted data protection, which has no performance penalty. Encryption is included in the Brocade 7850 base unit with no additional licenses or fees.

Acceleration of IP Extension Flows: WAN-Optimized TCP

TCP is central to the large data flow high-speed transport common with storage extension. Broadcom developed an aggressive TCP stack called WAN-Optimized TCP (WO-TCP), a specialized transport that outperforms competing WAN optimization products. WAN optimization provides a negligible benefit relative to the Brocade 7850. The total bytes transferred in the same amount of time and bandwidth will be nearly identical to competing WAN optimization, and Brocade Extension costs considerably less than WAN optimization products of the same bandwidth.

IP Extension accelerates TCP flows across the WAN improving IP storage performance. Distance increases latency and is prone to more packet loss, which severely degrades native IP storage performance. Applications tested with IP Extension demonstrate improvements of up to 50 times due to innovative techniques for handling latency and packet loss. Flow acceleration is purely a function of enhanced protocol efficiency across the network. Performance improvements are not related to compression; achievable compression is in addition to flow acceleration.

Brocade 7850 IP Extension locally terminates IP storage flows and repackages the data for transport using WO-TCP. The primary benefit is local acknowledgments (ACK). An IP storage device performs at high speed within the data center by localizing ACKs. Native IP storage TCP stacks can only perform at high speeds over short distances. Beyond the limits of the data center, droop, which is the inability of TCP to maintain line rate over distance, becomes a significant factor. Droop worsens progressively as distance increases.

WO-TCP is an aggressive TCP stack designed for significant data movement, operating on the purpose-built hardware of the Brocade 7850. WO-TCP has no droop across two 10Gb/s connections, up to 160-ms round-trip time (RTT) per data processor, equivalent to two fully utilized 10Gb/s WAN connections between Los Angeles and Hong Kong.

Another benefit is the absence of head of line blocking (HoLB) or slow drain device (SDD) problems with WO-TCP flows. WO-TCP on the Brocade 7850 implements a feature called streams. Streams mitigate HoLB and SDD problems across the IP WAN network. If all IP storage flows were flow-controlled using a single TCP receiver window (rwnd), all flows would slow if the rwnd is reduced. Flow control must be applied to individual flows, otherwise it harms other flows.

Creating a separate TCP connection for each flow is not practical, as this consumes excessive resources. Instead, autonomous streams are created using virtual TCP windows for each stream. The Brocade 7850 can accommodate hundreds of streams per data processor. Two data processors are present for each Brocade 7850 switch. Because a virtual TCP window is used for each stream, no other flows are affected if they need to slow down or stop; other flows continue running at their regular rate.

WO-TCP integrates with Adaptive Rate Limiting (ARL), and the synergy of these two technologies creates a robust storage transport. No storage array or tape sub-system has a similar native IP transport. WO-TCP demonstrates the enterprise-class performance of the Brocade 7850 for IBM TS7770 Grid implementations.

Bandwidth Management and Pooling

Bandwidth management and bandwidth pooling form a feature set that provides aggregate bandwidth from multiple sources and management of that bandwidth. Pooling and managing bandwidth uses Brocade Extension Trunking technology.

Jumbo Frames

The Brocade 7850 supports jumbo frames. If the IP WAN does not support jumbo frames, LAN-side replication devices can use jumbo frames to accelerate replication. Vice-versa, if the IP WAN supports jumbo frames but the data center does not, jumbo frames can be used across the WAN.

Brocade Extension Trunking

Brocade Extension Trunking was initially developed for mainframes and is now broadly used in open systems environments. Brocade Extension Trunking has evolved to include IP Extension, which is extensively used in IBM TS7770 Grid. Brocade Extension Trunking bundles multiple circuits into a single logical trunk. For redundancy, those circuits typically span multiple service providers and redundant data center network devices. Bandwidth is managed so that if a data center network device goes offline, the remaining paths adjust bandwidth to compensate for the offline path. A proper design maintains bandwidth during an outage of devices along the path. Brocade Extension Trunking shields end devices from IP network disruptions, making network failures transparent to replication traffic.

Multiple Brocade 7850 circuits are applied to various paths across the IP WAN network. With each added circuit, bandwidth is added to the pool. Brocade Extension Trunking performs deficit-weighted round robin (DWRR) scheduling when placing batches into the egress queue. Batches assemble FC frames and IP datagrams into compressed byte streams for transport across the WAN; the encapsulation process is called high-efficiency encapsulation.

A feature of Brocade Extension Trunking called lossless link loss (LLL) ensures lossless data transmission if data is lost in flight due to link loss and WO-TCP is no longer operational across that circuit. WO-TCP recovers lost or corrupted data across a link if a circuit is operational. All data is delivered to the upper-layer protocol (ULP) in order.

Brocade Extension Trunking performs failover and failback; no data is lost or delivered out of order during such events. Circuits can be designated as backup circuits, which are passive until all the active circuits within the failover group have gone offline. Brocade Extension Trunking supports the aggregation of multiple WAN connections with different latency and throughput characteristics, allowing WAN circuits to be procured from multiple service providers with different physical routes to ensure maximum availability. If all WAN circuits are from the same service provider, then a single failure event (for example, equipment failure, power loss, or cable cut) can take down all WAN circuits simultaneously. With Brocade Extension Trunking, organizations can protect their replication traffic from these outages.

Brocade Extension Trunking offers more than the ability to load balance and failover or failback data across circuits; it is a lossless function, providing in-order delivery. When data in flight is lost due to a path failure, it is retransmitted over remaining circuits and placed in order before sending to the ULP. IP storage applications are never subjected to data loss or out-of-order data.

When IP Extension is not used and native IP storage is used, packet loss in the IP network results in deficient performance. Native stacks have no tolerance for packet loss. On platforms experiencing 0.1% packet loss and 5-ms RTT, the reduction in throughput is 95% or more.

Using the Brocade Extension Trunking with IP Extension for IBM TS7770 Grid offers significant performance and availability enhancements that are not available with other solutions.

Adaptive Rate Limiting

Adaptive Rate Limiting (ARL) maximizes WAN utilization while sharing the IP WAN network with other non-storage applications. Native IP storage applications cannot adaptively alter rate limiting based on IP WAN conditions; the Brocade 7850 can. Based on conditions, ARL dynamically adjusts its bandwidth between the minimum and maximum rates to drive maximum I/O.

ARL is designed to work on WAN connections shared with other IP storage or non-storage applications. It automatically adjusts circuit rate limiting when circuits go offline, come online, or the available IP WAN bandwidth changes. Native array rate limiting was not designed for such instances. The Brocade 7850 can be configured so that high-priority applications maintain their bandwidth during an outage, while lower-priority devices sacrifice their bandwidth. ARL dynamically adjusts rate limits independent of each circuit, permitting efficient use of WO-TCP across various ever-changing WAN environments. For example, during a WAN service outage the overall bandwidth is halved, and Brocade ARL, integrated with WO-TCP, utilizes the available bandwidth while maintaining continuous operations.

ARL is used with Brocade Extension Trunking to maintain available bandwidth for storage applications. For example, suppose DC-LAN Switch A goes down. As long as DC-LAN Switch B remains online and has ample bandwidth connectivity, all of the original bandwidth to the application is maintained. It is necessary for rate limiting to adjust and compensate for the lost pathway. Rate limiting prevents oversubscribing the WAN and any associated contention or congestion. Congestion events force TCP to perform flow control, which is highly inefficient, slow to react, and results in poor performance. ARL adjusts from ordinary, not oversubscribed conditions to an outage condition that maintains bandwidth essential to continuous operations. ARL is an ideally unique performance optimizer for IBM TS7770 Grid implementations.

Prioritizing IP Extension Flows

Many IP networks provide no QoS service; in this case, storage delivery to the IP network can be based on application priority providing a first in, first out (FIFO) type of delivery. If the IP network can provide QoS service, Brocade Extension is located at the data transport endpoints where TCP originates and terminates. It is the most effective place to apply QoS markings to particular traffic flows.

Prioritization of flows across the WAN using QoS can be achieved in various ways. The first and simplest method is configuring priorities on the Brocade 7850 and feeding the prioritized flows into the IP network. Three priorities exist for FCIP (high, medium, and low), and three priorities exist for IP Extension (high, medium, and low), for a total of six priorities. In addition, the percentage of bandwidth apportioned to IP Extension and FCIP is configurable. When a flow uses a priority, the total bandwidth percentage is reserved even if it is not entirely used. The associated bandwidth is not reserved if there are no flows on a protocol or priority.

This first method prioritizes flows, relying on the Brocade 7850 to manage bandwidth when sending data to the WAN. With this method, the Brocade 7850 is the only network device requiring QoS configuration. The IP WAN network must perform FIFO for expected delivery.

The second method marks data flows as they exit the Brocade 7850. Data flows can be marked with IEEE 802.1P, part of 802.1Q virtual LAN (VLAN) tagging, or differentiated services code point (DSCP) end-to-end IP-based QoS. This method requires configuring the IP network for QoS service to honor the markings. If the IP network is not configured to do so, it does not prioritize the data flows. Implementing QoS in an IP network may involve a sizable project to categorize various flows and assign priorities. This approach is challenging because applications and priorities change over time, and the network may not remain consistent.

On the Brocade 7850, features such as QoS, 802.1P and DSCP marking are fully supported. Brocade 7850 users prioritize flows in an extension tunnel using high, medium, and low priorities. Then it is possible to create a service-level agreement (SLA) for the tunnel's circuits to best suit the environment.

When the IP Extension features of the Brocade 7850 are used with the IBM TS7770 Grid, enhanced reliability, scalability, security, and performance are achieved compared to IP connectivity on its own.

Brocade SANnav Management Portal

The Brocade 7850 is one component of an overall system that works to guard against disruption. Its features facilitate the quick resolution of support issues and determine the root cause of faults or degradation. Use Brocade SANnav Management Portal with Brocade Extension for IBM TS7770 Grid implementations to increase visibility, pinpoint problems, accelerate troubleshooting, and maximize performance.

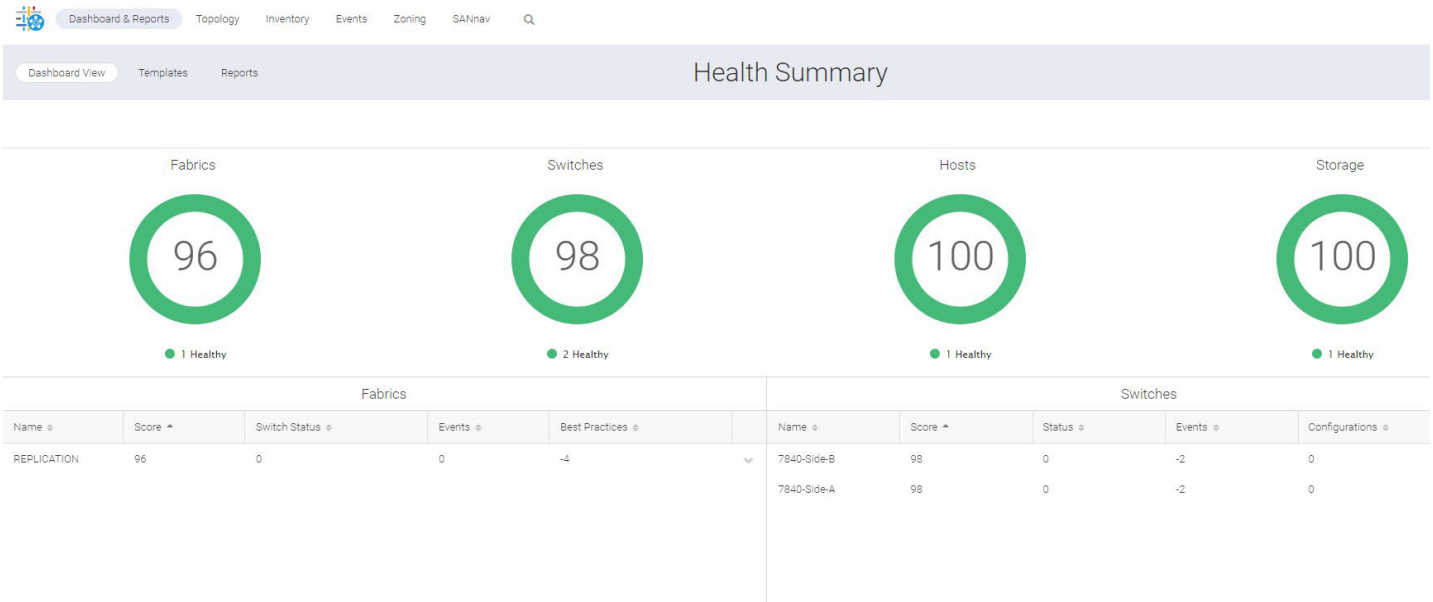
Recovery point objectives (RPO) for mission-critical applications can be five seconds or less, which is challenging when data rates are 10Gb/s or higher. Intermittent network outages and multiple vendors, such as storage, SAN, network, and service providers, exacerbate the challenge. These situations can cost organizations considerable money and potentially expose the business to data loss.

To address these problems within the context of extension, Brocade SANnav Management Portal introduced advanced capabilities for the Brocade 7850. Brocade SANnav Management Portal includes monitoring, alerting, and reporting tools specific to Brocade Extension. Diagnostic tools are also available for determining IP network validation and overall health. The objective is to determine the root cause of a degraded situation or outage and expedite a return to normal operations as quickly as possible. Brocade SANnav Management Portal provides an innovative solution that enables management of the Grid extension network in a much more proactive manner than previously possible. This section of the paper lists and briefly discusses these features and functionalities incorporated into Brocade Extension.

Brocade SANnav Management Portal Dashboard

Brocade SANnav Management Portal creates a Health Summary, as shown in Figure 4. The Health Summary displays the monitors, counters, and status indicators important to the Brocade 7850 and Grid environment. The Brocade SANnav Management Portal has a dashboard paradigm proven to significantly save time for performance management and troubleshooting. When what happens in the Grid network is clear, the goal of continuous uptime becomes a reality.

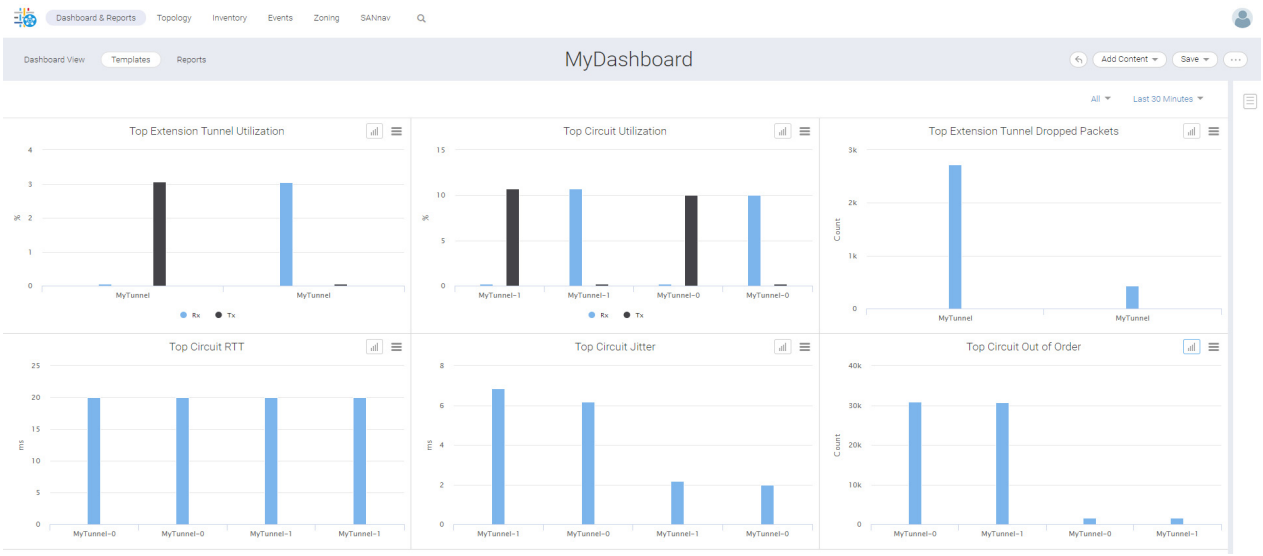
Figure 4: Brocade SANnav Management Portal Health Summary



Monitoring and Alerting Policy Suite

Brocade introduced the Monitoring and Alerting Policy Suite (MAPS) for Brocade Fabric OS® (Brocade FOS) and Brocade SANnav Management Portal to provide a comprehensive suite of monitors, alerts, actions, and reporting. MAPS assists operations in achieving higher availability, quicker troubleshooting, and infrastructure planning. MAPS provides a prebuilt, policy-based threshold monitoring and alerting tool that proactively monitors the health of the extension network based on a comprehensive set of metrics at the tunnel, circuit, and QoS layers (see Figure 5). Administrators can configure multiple fabrics simultaneously, using predefined or customized policies for specific ports and switch elements.

Figure 5: Brocade Extension Dashboard



MAPS monitors utilization, packet loss, RTT, jitter, and state changes for tunnels, circuits, and priority transmission queue (PTQ). Each PTQ priority (class-F, low, medium, and high) is monitored independently and includes throughput, duplicate acknowledgments (DupACK), out of order segments (OOOS), packet count, retransmits, and slow starts. Based on Brocade best practices, MAPS is simple and easy to deploy with preset threshold levels and responses (conservative, moderate, and aggressive). Virtually every element is customizable in MAPS. MAPS simplifies threshold configuration, monitoring, and alerting by leveraging prebuilt rules and policy-based templates. Organizations can configure one, multiple, or all fabrics using common rules and policies or customized policies for specific ports, switch elements, and items through a simple dialog. The integrated dashboard displays an overall switch health report and details on out-of-range conditions. Administrators can quickly pinpoint potential issues and easily identify trends and other aberrant behaviors within their fabric.

Flow Vision

The Flow Vision feature set enables administrators to identify, monitor, and analyze specific application flows to simplify troubleshooting, maximize performance, avoid congestion, and optimize resources. Flow Vision is a component of Brocade FOS and the Gen 7 ASIC. Flow Vision includes Flow Monitor, MAPS for Flow Monitor, and Flow Generator. The Brocade 7850 can monitor specific flows between F_Ports that communicate end-to-end across the Extension network. It is also possible to monitor flows that come in from an E_Port. At logical unit number (LUN) granularity, the input-output per second (IOPS) and data rate can be monitored.

Flow Vision is used to visualize flows through a tunnel and is an advantage of the Brocade 7850 in a Grid environment. Not all flows are equal, and a Brocade Extension tunnel allows visualization of each application's flows. Storage administrators monitor flow behavior to ensure SLAs are met. Monitoring network and flow behavior is complex if managed from each device and port.

Troubleshooting network flows takes time and effort. Storage administrators are not familiar with networks, and network administrators are not familiar with storage. These two groups have very different cultures and operating guidelines. It is difficult for storage administrators to depend on network administrators to maintain their replication environment, which makes flow, TCP, circuit, and tunnel monitoring and visualization all the more critical.

When troubleshooting storage flows, imagine that the flows fall into one of two categories: victims or perpetrators. If something goes wrong in the network, every flow becomes a victim. However, sometimes nothing is wrong with the network and flows fall victim to perpetrators. Perpetrator flows utilize excessive resources to the point that other flows fall victim. Falling victim to a perpetrator flow frequently happens downstream in the IP network. Brocade Extension provides features, functionality, and tools for dealing with storage SLAs. Flows within the protection of Brocade Extension meet their SLAs when facing perpetrator flows.

Flow Vision includes the following features:

- Flow Monitor - Provides comprehensive visibility into flows within the fabric, including the ability to learn flows and non-disruptively monitor flow performance automatically. Administrators can monitor replication flows from array to array.
- Flow Generator - Provides a built-in traffic generator for pretesting and validating data center infrastructure- including route verification and the integrity of optics, cables, ports, back-end connections, and ISLs-for robustness before applications are deployed.

Wtool

Wtool tests the WAN-side infrastructure from the local extension platform to the remote. Wtool creates data flows using the same circuits configured for the tunnel. Wtool uses the same circuits and configuration during testing, including source and destination IP addresses, MTU, network path, VLAN ID, IPv4 or IPv6, and IPsec. If a tunnel's circuit is administratively disabled, and then enabled with Wtool, the tunnel's other circuits remain online and operational while the selected circuit is decommissioned for testing.

Wtool runs in the background for a specified time. Users can disconnect during the test run without disrupting the test. Multiple test sessions can run simultaneously. On command, Wtool reports the new and previous run's results. Results include timestamp, throughput, RTT, packet loss, out-of-order packets, etc.

Brocade 7850 for Fibre Channel, FICON, and Grid Consolidation

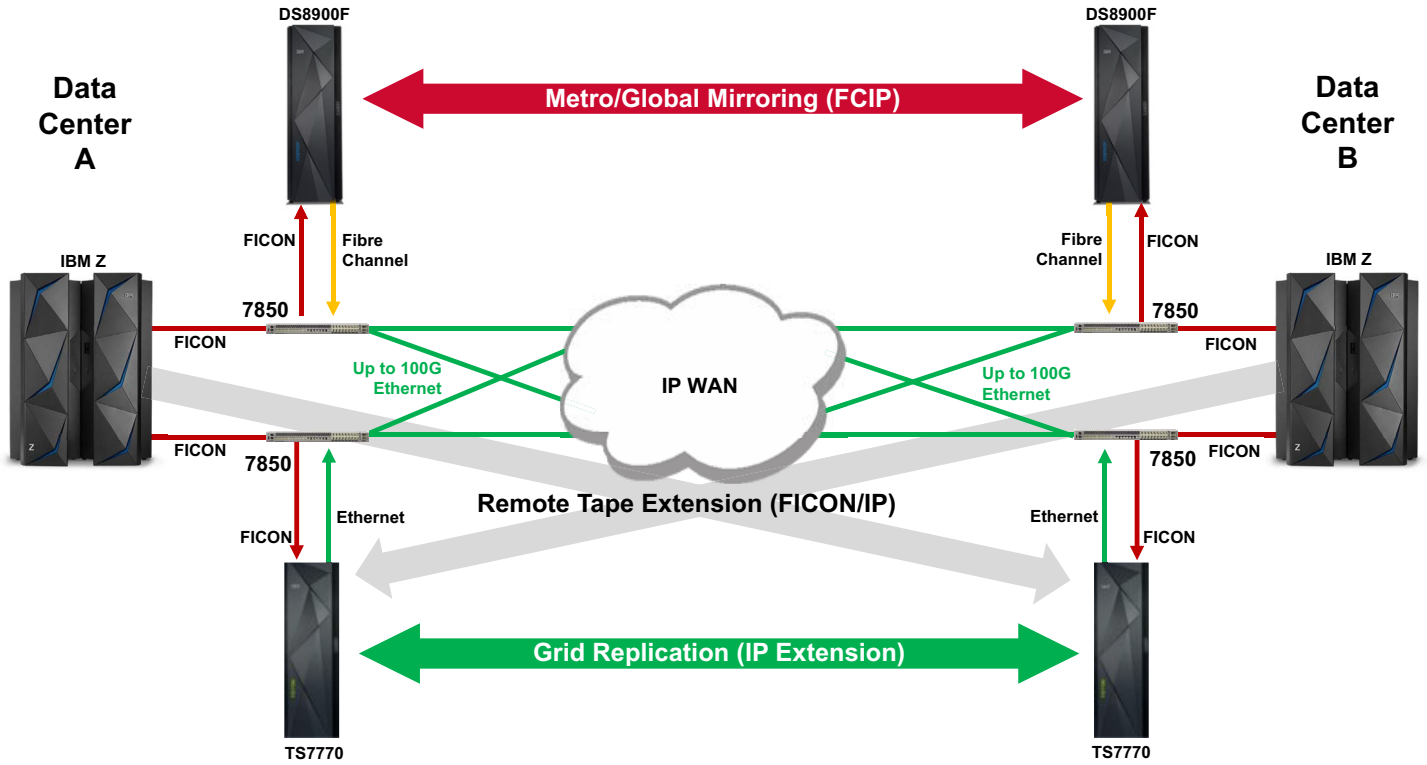
The Brocade 7850 is ideal for IBM TS7770 Grid and high-availability configurations. Local and remote hosts connect to local and remote clusters. If a local or remote cluster goes offline, tape processing continues for mission-critical applications. FICON uses FCIP, and Grid uses IP Extension across the same extension tunnel. Bandwidth management and transmit queue prioritization are done by the Brocade 7850 to ensure reliable operation and seamless access.

Separate FCIP and Grid flows across the WAN can be contentious and require continuous monitoring. Instead of Grid sharing WAN bandwidth with extension, it is joined into a tunnel that manages flow control and egress queue scheduling. The Brocade 7850 optimizes the FCIP and Grid flows for the highest performance without congestion or WAN oversubscription. Flows are managed by QoS, compression, encryption, and ARL without a complex network project that may result in protracted operational issues. The Brocade 7850 accelerates Grid data across the WAN using WO-TCP.

The Brocade 7850 manages traffic from FC, FICON, and IP applications. The Brocade 7850 uses FCIP with Metro Mirror and Global Mirror (PPRC). Extended Remote Copy (XRC) uses Advanced FICON Accelerator and FICON over IP, and IBM TS7770 Grid uses IP Extension.

As shown in Figure 6, clients can consolidate multiple cyber-resilient solutions onto a common infrastructure that supports many types of data replication. Clients can collapse their Metro/Global Mirroring using FCIP, TS7770 Grid using IP Extension, and Remote Tape Extension using FICON over IP onto a common extension backbone using the Brocade 7850.

Figure 6: Common Brocade 7850 Extension for IBM TS7770 Grid and Global Mirror



Summary

The IBM TS7770 Grid solution is crucial to IBM Z cyber resilience. The Brocade 7850 offers an innovative, unique IP Extension solution ideal for Grid, significantly increasing performance, security, and availability between data centers. Combined with the sophisticated Brocade SANnav Management Portal, these solutions enable users to distinguish network trouble from storage array problems. These practical tools facilitate more efficient support calls and faster problem resolution. The Grid solution with the Brocade 7850 offers end users a highly available, cyber-resilient mechanism for improving recovery point objectives (RPOs) and recovery time objectives (RTOs).

For more information about Brocade solutions, visit the Brocade 7850 product page.

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