Enhanced Resilient Solutions for Business Continuity

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Executive summary

Data availability and business continuity can be a vital competitive edge that is crucial to an organization's success. From finance, healthcare and transportation to retail and government agencies, organizations must adopt proven business continuity and recovery management strategies, and use the most effective storage technologies to successfully address operational risk, availability and security challenges. One way to achieve this is to plan and implement a resilient, responsive mainframe and extension solution designed to help you address external and internal demands, disruptions, disturbances, and threats, while continuing business operations without significant impact.

A key component of a resilient IT architecture for IBM® z Systems™ customers is the IBM TS7700 with a multicluster grid configuration. The TS7700 Grid configuration is a series of clusters connected by a network to form a highly available, resilient virtual tape storage architecture. Logical volume attributes and data are replicated by way of Internet Protocol (IP) across these clusters, which are joined by the grid network. However, to the host, the grid configuration looks like a single storage subsystem. This helps ensure high availability and that production work can continue, even if an individual cluster becomes unavailable.

IBM SAN42B-R Extension Switch and Fabric Vision technology enable TS7700 Grid users to gain significant increases in performance, security, reliability and availability between clusters in the grid network. This paper details the features and advantages provided by b-type Extension technology in a TS7700 Grid network.

Introduction: Resilient IT architectures

A resilient IT architecture helps organizations better respond and adapt to a wide variety of external and internal demands, disruptions, disturbances and threats while continuing business operations without significant impact. Although related to planning for disaster recovery, planning for a resilient IT architecture is much broader in scope. A resilient IT architecture requires organizations to go beyond planning for recovery from an unplanned outage. A properly designed resilient IT architecture enables organizations to avoid outages almost entirely to help ensure business continuity.

In any business continuity architecture, the most expensive component typically is the network bandwidth for connectivity between sites. The goal in designing TS7700 Grid architecture is to maximize IT resiliency at the lowest cost. In other words, this architecture maximizes network efficiency using easy-to-manage connectivity devices that offer extremely high performance and availability with low operating costs. The IBM SAN42B-R Extension Switch offers these benefits.

With a TS7700 Grid network connected to the SAN42B-R, z Systems customers can achieve a highly resilient architecture that is optimized for performance and availability. This architecture is designed to simplify management of the entire TS7700 network environment using a "single pane of glass" in conjunction with IBM Network Advisor and Fabric Vision management software.

This white paper explains the basics of the TS7700 Grid solution, and describes the features and technologies available from IBM that help ensure an optimal TS7700 Grid solution.

Challenges in designing a resilient IT architecture

Few events can generate a stronger adverse business impact as an IT outage, even if it lasts for only a few minutes. The negative publicity that such events often generate in today's "always connected" news media world can be extremely detrimental. Clients, partners and the market are driving the demand for continuously available, resilient IT architectures. The potential revenue loss from an outage and the damage to a company's reputation can be costly. Plus, the possible government sanctions in an increasingly complex regulatory environment can create even more challenges.

Companies across a diverse spectrum of industries face these growing challenges when planning a resilient IT architecture. Executive focus on resilient IT architecture solutions, such as the TS7700 Grid, is increasing because it is no longer enough to merely plan for recovery from a disaster. Enterprises that run z Systems need a greater level of availability to deal with a range of contingencies. These contingencies can be as simple as inadvertent power loss or common configuration errors, or as complex as major natural disasters like a hurricane or human-induced disasters such as terrorism. A business that plans for a resilient IT architecture must implement both traditional disaster recovery planning and additional planning for continuous availability.

As data centers and data stores grow, tape operations become more complex. Growth can also lead to increased tape processing times, high management expenses and skyrocketing hardware costs. For high availability and disaster recovery, the TS7700 can be deployed in several networked, multisite grid configurations. Each grid configuration is optimized to help eliminate downtime from planned and unplanned outages, upgrades and maintenance. The TS7700 Grid enhances the resilience of an organization's IT architecture.

The network infrastructure that supports a TS7700 Grid solution has certain requirements. First, the network components need to individually provide reliability, high availability and resiliency because the overall solution is only as good as its individual parts. A TS7700 Grid network requires components that

provide nonstop, predictable performance with 99.999 percent uptime. Second, a TS7700 Grid network must be designed with highly efficient components that minimize operating costs. Third, today's rapidly changing and growing amounts of data require a TS7700 Grid network that uses highly scalable components to support business and application needs. Companies also need to consider future deployment of new technologies as they become available.

TS7700 Grid basics

A prior-generation technology produced the IBM Virtual Tape Server (VTS), which had a feature called peer-to-peer (PtP) VTS capabilities. PtP VTS was a multisite-capable business continuity and disaster recovery solution. PtP VTS was to tape what Peer-to-Peer Remote Copy (PPRC) was to direct access storage devices (DASDs). PtP VTS-to-VTS data transmission was originally done by IBM Enterprise Systems Connection (IBM ESCON), then IBM FICON®, and finally using Transmission Control Protocol/Internet Protocol (TCP/IP) for the introduction of the TS7700.

With the TS7700, using TCP/IP for extension, the virtual tape controllers and remote channel extension hardware for the prior-generation PtP VTS were eliminated. This change provided the potential for significant simplification in the infrastructure needed for a business continuity solution and simplified management. Hosts attach directly to the TS7700s. Instead of FICON or ESCON, the connections between the TS7700 clusters use standard TCP/IP. Similar to the previous-generation PtP VTS, with the new TS7700 Grid configuration, data can be replicated between the clusters based on the customer's established policies. Data can be accessed through any of the TS7700 clusters, regardless of which system the data resides, if the grid contains at least one available copy.

As a business continuity solution for high availability and disaster recovery, multiple TS7700 clusters are interconnected by using standard Ethernet connections. Local and geographically separated connections are supported to provide a greater amount of flexibility to address customer needs. This IP network for data replication between TS7700 clusters is more commonly known as a TS7700 Grid. A TS7700 Grid refers to two to six physically separate TS7700 clusters that are connected to each other with a customer-supplied IP network. The TCP/IP infrastructure that connects a TS7700 Grid is known as the grid network. This grid configuration is used to form a high-availability disaster recovery solution, and provide metro and remote logical volume replication. The clusters in a TS7700 Grid can be, but do not need to be, geographically dispersed. In a multiple-cluster grid configuration, two TS7700 clusters are often located within 100 kilometers (km) of each other. The remaining clusters can be more than 1,000 km away. This solution provides a highly available and redundant regional solution. It also provides a remote disaster recovery solution outside of the region.

The TS7700 Grid configuration introduces new flexibility for designing business continuity solutions. PtP communication capability is integrated into the base architecture and design. No special hardware is required to interconnect the TS7700s. The Virtual Tape Controllers (VTCs) of previous generations of PtP VTSs are eliminated, and the interconnection interface is changed to standard IP networking. If configured for high availability, host connectivity to the virtual device addresses in two or more TS7700s is required to maintain access to data if one of the TS7700s fails. If the TS7700s are at different sites greater that typical FICON extension for Metro solutions, then longer range channel extension equipment is required to extend the host connections.

With the TS7700 Grid, data is replicated and stored in a remote location to help enable continuous uptime. The TS7700 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 business continuity solutions, so that organizations can simplify their storage environments and optimize storage utilization. This functionality is similar to Metro Mirror and Global Mirror with advanced copy services support for z Systems customers.

Because the TS7700 Grid is a robust business continuity and IT resilience solution, organizations can move beyond the inadequacies of on-site disk-to-disk or disk-to-tape backups that cannot protect against regional, nonlocal natural or human-induced disasters. By using the TS7700 Grid, data can be created and accessed remotely through the grid network. Many TS7700 Grid configurations rely on this remote access to further increase the importance of the TCP/IP fabric.

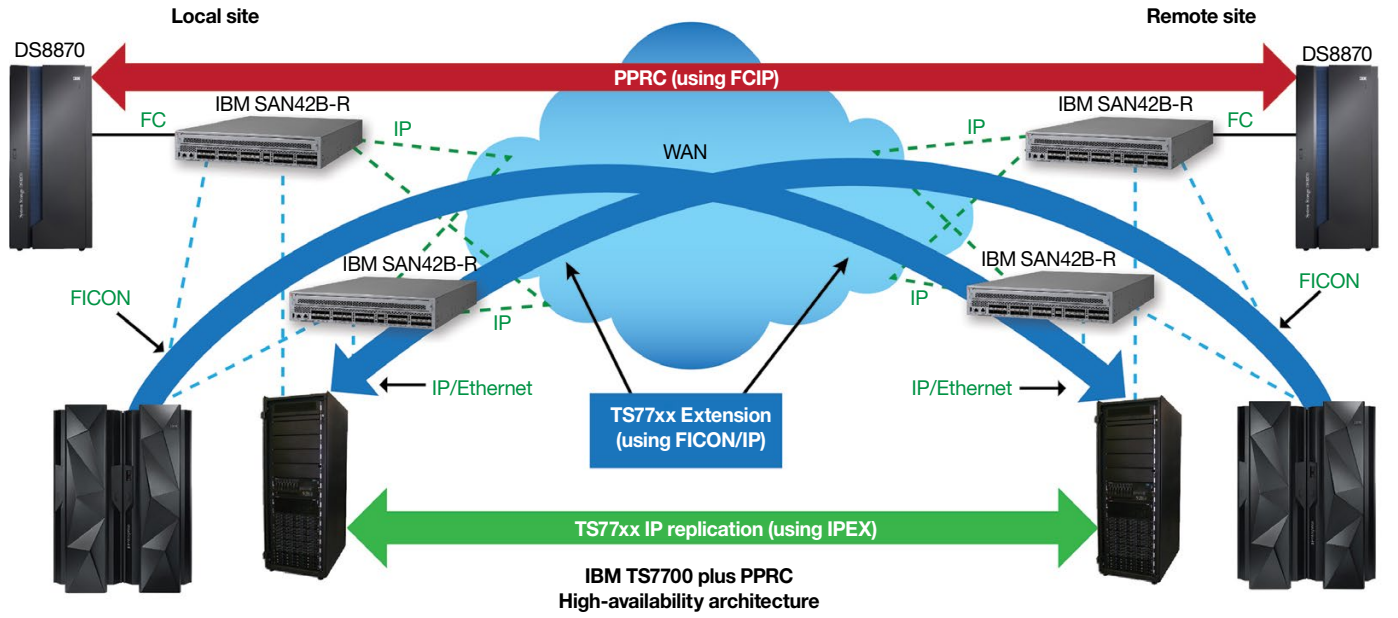

Figure 1. TS7700 Grid plus PPRC high-availability architecture

With increased storage flexibility, an organization can adapt quickly and dynamically to changing business environments. Switching production to a peer TS7700 can be accomplished in a few seconds with minimal operator skills. With a TS7700 Grid solution, z Systems customers can significantly reduce planned and unplanned downtime. This approach can potentially save thousands of dollars in lost time and business, and can address today's stringent government and institutional data protection regulations.

IBM System Storage SAN42B-R Extension Switch basics

IBM SAN42B-R is a purpose-built extension solution. It is an enterprise-class product characterized by an essential feature set: excellent performance, increased security, high reliability, proactive monitoring, flow visibility and diagnostic tools. The SAN42B-R is an ideal platform for building a high-performance data center extension infrastructure for replication and backup solutions. It leverages virtually any type of inter-data center wide area network (WAN) transport to extend open systems and mainframe storage applications over virtually any distance. Without the use of an extension, those distances are often impossible or impractical. In addition, the SAN42B-R addresses the most demanding disaster recovery requirements. With twenty-four 16 gigabit-per-second (Gbps) Fibre Channel (FC)/FICON ports, sixteen 1/10 Gigabit Ethernet (GbE) ports, and two 40 GbE ports, customers can achieve the bandwidth, port density, and throughput required for maximum application performance over WAN connections.

IBM b-type technology integrates seamlessly into virtually any IP network and provides a highly efficient data transport capable of full bandwidth utilization across great distances.

The defining features that bring value to b-type Extension in TS7700 Grid environments include extension hot code load (HCL), extension trunking, WAN-optimized TCP (WO-TCP), IP security (IPsec), adaptive rate limiting (ARL), data compression, Fabric Vision technology and IBM Network Advisor. IBM also provides a full spectrum of security features and connectivity validation tools. Overall, IBM b-type Extension products leverage 20 years of distance connectivity innovation and thought leadership, as demonstrated by the fact that they are the market's preferred extension solution.

The SAN42B-R is capable of Fibre Channel over IP (FCIP) extension and IP extension. Therefore, the SAN42B-R provides an ideal platform for TS7700 Grid connectivity, for both high-availability and disaster recovery configurations. An additional benefit is that DASD, along with the TS7700, can leverage these DR configurations built with the SAN42B-R, thus providing even greater ROI and optimal usage of hardware and extended links. This section of the white paper discusses some basics of the SAN42B-R. The remainder of the white paper does not focus on the FCIP extension capabilities of the SAN42B-R; rather, it focuses on IP extension specifics as they pertain to the TS7700 Grid replication.

SAN42B-R Extension hot code load

Extension HCL was introduced to the storage industry with the SAN42B-R. Firmware upgrades can be done without tunnel disruption, but can take considerable time—often longer than a company can allow a large extension connection to stay down. In the past, WAN links had lower-capacity bandwidths, and it was not paramount to maintain connectivity during firmware updates. The interim backlog of data was acceptably small. However, by today's standards the amount of backlog data during a firmware upgrade can be significant, on the order of half a terabyte or more when using one 10 Gbps connection.

At many enterprises, to comply with recovery point objective (RPO) policy and maintain a comfort level for storage administrators, nonstop operations of TS7700 Grid replication are required. The SAN42B-R is the only product on the market that maintains extension connectivity during a firmware upgrade. Extension HCL from IBM is virtually lossless and designed to keep data in-order. During the firmware update process no data is lost, and all data sent to upper-layer protocol (ULP) is consistent and in order. This means that Extension HCL can be used in mainframe environments without causing interface control checks (IFCCs), which is a testament to the underlying advancements to this technology.

Security of IP extension flows: IPsec

Unsecured data leaving the data center potentially could cause data breaches—and even unwanted publicity—for an enterprise. Increasingly, users are facing requirements to encrypt all data that leaves the data center, known as encryption in flight. These requirements are typically driven by government regulations, internal audit requirements or a combination of the two. Any data that leaves the safe confines of the data center should be protected using encryption. Encryption applies not only to the public Internet because even private WAN connections are not secure outside of the data center.

Hardware-based Internet Protocol Security (IPsec) has been developed to secure data in-flight across b-type Extension inter-switch links (ISLs). IPsec operates at line-rate and introduces only a couple of microseconds (µs) of added latency, making it useful for synchronous applications. IPsec uses AES-GCM-256, Diffie-Hellman 2048-bit Modular Exponential (MODP), Internet Key Exchange version 2 (IKEv2), Hash-Based Message Authentication Code 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 per tunnel and trunk on each side.

Best practice with TS7700 Grid networks is to use IPsec for extension. IPsec is part of circuit formation. It protects data from virtually every type of attack, including sniffers, data modification, identity spoofing, man-in-the-middle and denial of service (DoS) attacks. It requires no additional licenses or costs and is designed to be simple to configure. IPsec plus extension trunking provides the ability to granularly load balance encrypted storage flows across all the trunk's member circuits. Up to 20 Gbps is supported for a single trunk, and two such trunks are supported per SAN42B-R switch. This is a large amount of encrypted load-balanced data bandwidth of 40 Gbps for a single box. IPsec also prevents the need for costly and complex firewalling. Because firewalls are software-based, they tend to provide poor performance.

The SAN42B-R with IPsec encourages the use of encrypted data protection and does so with no performance penalty. This capability is hardware-implemented and operates at line rate of 20 Gbps per data processor, with 5 µs of added latency. IPsec is included in the SAN42B-R base unit with no additional licenses or fees. The IPsec implementation offers better performance than the TS7700 native-based encryption solution, while providing prudent security at no additional cost.

Acceleration of IP extension flows: WO-TCP

Optimal utilization of an available ISL bandwidth is key to reducing upfront and ongoing cost for the client. Through years of extension experience using TCP for high-speed transport for large data sets common for storage extension, an aggressive WAN Optimized TCP stack (WO-TCP) was developed and implemented in the SAN42B-R specifically for IP Extension solutions. WO-TCP is a specialized transport that outperforms competing WAN optimization products.

In other words, WAN optimization provides a negligible benefit when using the SAN42B-R. Overall, b-type technology is comparable from the perspective of the data transport bottom line. The total bytes transferred within the same period of time, over the same bandwidth, will be virtually the same compared to competing WAN optimization products. All of these benefits are provided, plus the added satisfaction that the cost of purchasing b-type Extension is considerably less compared to WAN optimization products.

Acceleration of flows across the WAN improves IP storage performance dramatically. Long distance increases latency and is prone to packet loss. Tested applications have demonstrated improvements of up to 50 times[1], due to the ability to handle latency and packet loss without performance degradation. This performance has nothing to do with compression; any compression achievable is in addition to flow acceleration. Flow acceleration is purely a function of enhanced protocol efficiency across the network.

IP extension on the SAN42B-R terminates IP storage TCP flows locally and transports the data across the WAN using WO-TCP. The primary benefit here is the local acknowledgement (ACK). By limiting ACKs to the local data center, TCP that originates from an end IP storage device has to be capable of merely high-speed transport within the data center. Most native IP storage TCP stacks are capable only of high speeds over short distances. Beyond the limits of the data center, "droop" becomes a significant factor. Droop refers to the inability of TCP to maintain line rate across distance and worsens progressively as distance increases.

WO-TCP is an aggressive TCP stack designed for big data movement, operating on the purpose-built hardware of the SAN42B-R switch. The IBM SAN42B-R offers 64 processors and 128 gigabytes (GB) of RAM to support WO-TCP. In comparison, WOTCP has no droop across two 10 Gbps connections, up to 160 milliseconds (ms) round-trip time (RTT) per data processor. This is equivalent to two fully utilized 10 Gbps WAN connections (OC-192) 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 streams. WO-TCP on the SAN42B-R implements a feature called "streams." Streams are used to mitigate HoLB and SDD problems across the IP network and WAN. If all IP storage flows are flow controlled, using a single TCP Receiver Window (RWND), then those flows slow or halt in the event that the TCP RWND is shut or closed. This situation is detrimental to all applications except for the one that flow control is meant for.

It is not practical to create a separate TCP connection for each flow as this consumes excessive resources. Instead, autonomous streams are created using virtual TCP windows for each stream. The SAN42B-R can accommodate hundreds of streams per data processor. Two data processors are present for each SAN42B-R switch. Because a virtual TCP window is used for each stream, if a flow needs to slow down or stop, no other flows are affected; they continue to run at their full rate.

WO-TCP integrates with ARL, and the synergy of these two technologies creates an industry-dominating transport for storage. No similar transport exists on any storage array or virtual tape system-based native IP replication. Clearly, WO-TCP demonstrates the enterprise-class performance superiority of the SAN42B-R for TS7700 Grid implementations.

Latency (ms) RTT	Approximate distance uni-direction	No packet drop		1 percent packet drop	
1 ms = ~100 miles	Between site A and site B	TS7700 with IP Extension	TS7700 Native Extension	TS7700 with IP Extension	TS770 Native Extension
2	100	590	590	590	16
20	1,000	590	590	590	12
100	5,000	560	65	540	5
250	12,500	540	25	540	3

Table 1. WO-TCP versus native TS7700 replication

Bandwidth management and pooling

Bandwidth management and pooling form a feature set that provides aggregate bandwidth from multiple sources, including high availability, and management of that bandwidth. This feature set uses the exclusive extension trunking technology on the SAN42B-R switch. The SAN42B-R switch also supports jumbo frames. Even if the IP network or WAN does not support jumbo frames, replication devices can still use local area network (LAN)-side jumbo frames, which should offload the CPU workload from the device and accelerate replication.

Extension trunking for the SAN42B-R

Extension trunking is a Brocade technology originally developed for mainframes and now broadly used in open systems environments. It has evolved to include IP extension flows. Extension trunking bundles multiple circuits together into a single logical trunk. Those circuits can span multiple service providers and different data center LAN switches for redundancy. Bandwidth is managed in such a way that if a data center LAN switch goes offline or encounters any disruption along the path, the bandwidth of the remaining paths adjusts to compensate for the offline path. With the proper design, bandwidth can be maintained during outages of various devices in the pathway. Extension trunking shields end devices from IP network disruptions, making network path failures transparent to replication traffic. Multiple circuits of two or more from the SAN42B-R are applied to various paths across the IP network. With each added circuit, even more bandwidth is added to the pool. Extension trunking performs a deficit-weighted round-robin (DWRR) schedule when placing batches into the egress. Batches are an efficiency technique used by the SAN42B-R to assemble frames into compressed byte streams for transport across the WAN. Lossless link loss (LLL), a feature of extension trunking, ensures lossless data transmission across the trunk in the event that data is lost in flight due to an offline circuit and WO-TCP is no longer operational across that circuit. WO-TCP itself recovers lost or corrupted data across a link if that circuit is still operational. All data is delivered to ULP in-order.

The most common example of this is redundant data center LAN (DC-LAN) switches. For instance, one circuit goes over DC-LAN Switch A, and the other circuit goes to DC-LAN Switch B. This is a simple and effective architecture for redundancy and increased availability. Of course, as needs dictate,

the application of circuits over various paths and service providers, with up to eight circuits per IP extension tunnel, can establish a highly available infrastructure for IP storage.

Extension trunking performs failover and failback, and virtually 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. This protects users against a WAN link failure and avoids a restart or resync event. Extension trunking supports aggregation of multiple WAN connections with different latency or throughput characteristics up to a 4:1 ratio, allowing WAN circuits to be procured from multiple service providers with different physical routes, ensuring maximum availability. If all WAN circuits are from the same service provider, then chances are high that a single failure event can take down all WAN circuits at one time. A single failure event could include an equipment failure, power loss or a cut cable. With extension trunking, organizations can protect their replication traffic from these kinds of outage events.

Extension trunking offers more than the ability to load balance, and failover or failback data across circuits. It is also a lossless function, providing in-order delivery within an extension trunk, defined by a virtual expansion Port or VE_Port. Even when data in flight is lost due to a path failure, data is retransmitted over remaining circuits by way of TCP and placed back in order before it is sent to ULP.

Normally, when IP extension is not used, packet loss in the IP network results in extremely low performance on native IP storage TCP/IP stacks. These stacks have little to no tolerance for packet loss across the IP network. On popular network-attached storage (NAS) platforms during periods of 0.1 percent packet loss and 5 ms RTT latency, the reduction in throughput is 95 percent or more.

Using the Extension trunking feature with IP extension for TS7700 Grid implementations offers significant performance and availability enhancements that are not available with other solutions.

Adaptive rate limiting

ARL is used to maximize WAN utilization, while sharing a link with other non-storage applications. Native TCP/IP stacks on IP storage applications do not have the ability to adaptively alter rate limiting based on conditions in the IP network. However, the SAN42B-R Extension Switch does have this ability. ARL dynamically adjusts shared bandwidth between minimum and maximum rate limits and drives maximum I/O, even with a downed redundant system.

ARL automatically adjusts the rate limiting on all associated circuits that replicate across the IP network, regardless of the ingress FC device and the WAN path or paths. In addition, ARL automatically adjusts rate limiting when other Extension circuits go online and offline or when the available IP bandwidth that is being experienced changes. It works across all b-type Extension products using the same WAN infrastructure.

ARL is designed to work on WAN connections that are shared with other IP storage or non-storage applications. Array auto-adjust rate limiting was not designed for such instances. In fact, the SAN42B-R can be configured so high-priority applications can maintain their bandwidth during an outage, while lower-priority devices sacrifice their bandwidth. ARL dynamically adjusts rate limits independent to each circuit, permitting efficient use of WO-TCP across a variety of ever-changing WAN environments. In this example, during the WAN service outage the overall bandwidth is halved and the ARL, integrated with WO-TCP, best utilizes the available bandwidth, while maintaining nonstop operations.

ARL is used with extension trunking to maintain available bandwidth to storage applications. For example, if DC-LAN Switch A goes down, as long as DC-LAN Switch B remains online and has ample bandwidth connectivity, it should be able to maintain all of the original bandwidth to the application. In this case, it is necessary for rate limiting to readjust upward and compensate for the lost pathway. Rate limiting is used to prevent oversubscribing the WAN and any associated contention or congestion. Congestion events force TCP to perform flow control, which is extremely inefficient, slow to react and results in poor performance. ARL adjusts from a normal condition that is not oversubscribed, to an outage condition that maintains the same bandwidth. Clearly, this is essential to continuous availability. ARL, in conjunction with the extension trunking feature, is an ideally unique performance optimizer for TS7700 Grid implementations.

Prioritizing IP extension flows (QoS)

Frequently, the IP network does not have quality of service (QoS) configured, at least for storage applications. Therefore, at a minimum, it is important to deliver data to the IP network that is sequenced according to the storage administrator's priorities. The Extension is located at the endpoints of the data transport, the TCP points of origin and termination. These endpoints are the most effective place to QoS-mark data and apply it to various applications. Prioritization of flows across the WAN using QoS can be achieved in various ways. The first and simplest method is to configure priorities on the SAN42B-R and feed the prioritized flows into the IP network. Three priorities exist for FCIP: high, medium and low, and three exist for IP extension: high, medium and low for a total of six priorities. In addition, the percentage of bandwidth during contention that is apportioned to IP extension and FCIP is configurable. When there is no contention for bandwidth, all available bandwidth can be utilized by a flow. This first method prioritizes flows that are connected to the LAN side of the SAN42B-R. The SAN42B-R manages bandwidth when sending data to the WAN. The only network device that requires QoS configuration with this method is the SAN42B-R. It is up to the IP network and WAN to perform first-in first-out (FIFO) operations, so that QoS works properly.

The second method is to mark data flows as they exit the SAN42B-R and enter the IP network. Data flows can be marked with IEEE 802.1P, which is part of 802.1Q virtual LAN (VLAN) tagging or Differentiated Services code point (DSCP), or end-to-end IP-based QoS. The difficulty in using this method is that it requires the IP network to be configured

to perform the proper actions based on the marking. If the IP network is not configured to do so, it does not prioritize the data flows. This usually entails a complex and sizable project on the IP network side, involving categorizing a diverse number of flows and assigning priorities to the flows. A problem with this approach is that QoS in the IP network does not remain stable. Applications and priorities change over time.

On the SAN42B-R, features such as QoS, 802.1P and DSCP marking are fully supported. Typically, SAN42B-R users prioritize their flows within the FCIP+IP extension tunnel. It is then possible to create a service level agreement (SLA) for the tunnel itself, so that QoS can be deployed in the manner best suited for the environment.

When the IP extension features of the SAN42B-R are used with the TS7700 Grid, enhanced reliability, scalability, security and performance is achieved compared with simple IP switching connectivity on its own.

Fabric Vision technology for TS7700 Grid

The SAN42B-R is one component of an overall system that works together to guard against disruption. The SAN42B-R has certain features that can facilitate the quick resolution of support issues and determine the root cause of faults or degradation. Extending Fabric Vision technology over distance for TS7700 Grid implementations delivers increased visibility, pinpoints problems and accelerates troubleshooting to maximize performance.

RPOs for mission-critical data typically require less than five seconds. These RPOs are difficult to maintain when data rates are 10 Gbps or higher and when network problems are also present. Often, multiple vendors are involved, such as storage vendors, storage network vendors, IP network vendors and WAN service providers. These situations can cost organizations considerable sums of money and potentially expose the business to data loss.

To address these problems within the specific context of the extension, Fabric Vision technology was introduced with advanced capabilities for the SAN42B-R. Fabric Vision includes monitoring, alerting and reporting tools that are specific to b-type Extension. Diagnostic tools are also available that are useful for determining IP network validation and overall health. The objective is to quickly determine a root cause of degraded situations or outages, and to expedite a return to normal operations as quickly as possible. Fabric Vision provides an innovative solution that enables management of the TS7700 Grid network in a more proactive manner than previously possible. This section of the paper lists, and briefly discusses, these features and functionalities that are incorporated into b-type Extension. For a more detailed discussion, please refer to the IBM white paper, *The Benefits of Fabric Vision Technology for Disaster Recovery* at **ibm.com**/common/ssi/cgi-bin/ssialias?subtype=WH&infotype=SA&htmlfid=TSW03329USEN&attachment=TSW03329USEN.PDF.

IBM Network Advisor dashboard

IBM Network Advisor uses a customizable dashboard, as shown in Figure 2. The IBM Network Advisor dashboard makes visible the monitors, counters and status indicators that are most important for the SAN42B-R and TS7700 Grid environment on a "single pane of glass." Organizations can choose from over one hundred dashboard items or, if the item they need does not exist, they can create the item. The IBM Network Advisor dashboard management paradigm can be a significant time-saver for performance management and troubleshooting. When what happens in the TS7700 Grid network environment is clear, the goal of continuous uptime becomes a reality.

Figure 2. The IBM Network Advisor dashboard

Monitoring and Alerting Policy Suite

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

MAPS monitors utilization, packet loss, RTT, jitter, and state changes for tunnels and trunks, circuits, and Per-Priority TCP Quality of Service (PP-TCP-QoS). Each PP-TCP-QoS priority, class-F, low, medium, and high, is monitored independently and includes throughput, duplicate ACKs, WO-TCP packet count, packet loss and slow-starts. MAPS is designed to be simple and easy to deploy with preset threshold levels and responses, conservative, moderate, and aggressive, based on Brocade best practices. As needed, though not required, virtually every element is customizable in MAPS. By leveraging prebuilt rules and policy-based templates, MAPS simplifies threshold configuration, monitoring and alerting. Organizations can configure one, multiple or all fabrics at once using common rules and policies, or they can customize policies for specific ports, switch elements and items—all through a single dialog. The integrated dashboard displays an overall switch health report, along with details on any out-of-range conditions. Administrators can quickly pinpoint potential issues and easily identify trends and other aberrant behaviors occurring within their fabric.

Flow Vision

The Flow Vision diagnostic tool enables administrators to identify, monitor and analyze specific application and data flows in order to maximize performance, avoid congestion and optimize resources. Flow Vision includes Flow Monitor, MAPS for Flow Monitor and Flow Generator.

Visualization of flows through tunnels by way of Flow Vision is another advantage of using the SAN42B-R in a TS7700 Grid environment. Not all flows are created equal, and a tunnel managed by IBM, allows administrators to visualize each application. To ensure that SLAs are being met, storage administrators monitor network and flow behavior. This is very difficult to accomplish if managed from each originating device and port.

Troubleshooting network flows is often a difficult and daunting endeavor. To make matters worse, storage administrators are not familiar with IP networks, and IP 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 solely on network administrators to maintain their replication environment, which makes flow, TCP, circuit, and tunnel monitoring and visualization considerably more important to manage.

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 are flows that utilize excessive resources to the point that other flows fall victim. This frequently happens downstream from the storage handoff to IP networking. Extension provides features,

functionality and tools to deal with storage SLAs. Flows within the protection of Extension tunnels meet their SLAs when they face perpetrator flows.

The feature set called Flow Vision enables administrators to identify, monitor and analyze specific application flows in order to simplify troubleshooting, maximize performance, avoid congestion and optimize resources. The SAN42B-R has the capability to monitor specific flows between F_Ports that are communicating end-to-end across the extension network. It is also possible to monitor flows that come in from an E_Port. Flow Vision is a component of FOS and the Gen5 application-specific integrated circuit (ASIC). At logical unit number (LUN) level granularity, input/output operations per second (IOPS) and data rate can be monitored. Flow Vision includes the following features:

- **Flow Monitor:** Provides comprehensive visibility into flows within the fabric, including the ability to automatically learn flows and non-disruptively monitor flow performance. Administrators can monitor all flows from a specific host to multiple targets or LUNs, from multiple hosts to a specific target or LUN, or across a specific ISL. Additionally, they can perform LUN-level monitoring of specific frame types to identify resource contention or congestion that is impacting application performance.
- **Flow Generator:** Provides a built-in traffic generator for pretesting and validating the data center infrastructure, including route verification and integrity of optics, cables, ports, back-end connections and ISLs, for robustness before deploying applications.

WAN tool

WAN tool is an IP-specific tool for testing the WAN-side infrastructure on the SAN42B-R. This tool creates data flows that use the same circuits configured in a tunnel or trunk. Since WAN tool uses the same circuit, all the characteristics of that circuit remain viable during testing, including jumbo frames, such as the path maximum transmission unit (PMTU), VLAN, IPv4/ IPv6 and IPsec. If a circuit in a trunk is selected with WAN tool, the trunk's other circuits remain online and operational while the selected circuit is decommissioned for testing.

WAN tool runs in the background and for a specified amount of time. The amount of time that can be set is nearly limitless. Users can disconnect WAN tool during the interim without halting or losing the test in progress. Also, multiple test sessions can run simultaneously. On command, WAN tool reports the new results, as well as the results of the previous run: time-stamp, throughput, RTT, packet loss and out-of-order packets.

SAN42B-R for consolidation

The SAN42B-R is capable of both traditional FICON FCIP and IP extension. Therefore, it is an ideal platform to use in TS7700 Grid disaster recovery and high-availability configurations. In the TS7700 high-availability architecture, it is necessary for the local TS7700 cluster to communicate with the remote cluster or clusters, and possibly for the remote cluster to communicate with the local cluster. In the event that either the local or remote cluster is offline, tape processing can continue for mission-critical applications, such as SAP. Both hosts have connectivity to the remote cluster. The FICON connection across the WAN uses a FCIP extension over the same tunnel. Bandwidth and prioritization are managed by the SAN42B-R to ensure reliable operation.

As for the IP connection between local and remote TS7700 clusters, sharing the WAN connection with FCIP is often contentious and must be continuously monitored and managed. The TS7700 Grid IP connectivity is managed by a single WAN scheduler and is joined into the extension tunnel on the SAN42B-R. The SAN42B-R optimally manages both the FCIP and IP extension flows for optimal performance without contention or oversubscription on the WAN. Flows can further be managed with QoS, compression, IPsec and ARL without involving long, complex projects on the network side that might cause ongoing operational issues. The SAN42B-R accelerates data transfers across the WAN by using WO-TCP technology.

Finally, the SAN42B-R has the ability to manage applications that operationally use a combination of FC+IP or FICON+IP. For example, the SAN42B-R could be used for the IBM z/OS® Global Mirror extension with FICON protocol and IBM Advanced FICON Accelerator emulation technology, in conjunction with managing the TS7700 Grid IP replication by way of its IP extension functionality and features.

Summary

The IBM TS7700 Grid solution is a key component to z Systems disaster recovery and business continuity implementations. The SAN42B-R offers an innovative, unique IP extension solution for TS7700 Grid implementations to gain significant increases in performance, security and availability between data centers. These solutions, combined with the sophisticated tools of Fabric Vision technology, enable you to distinguish trouble with the network from storage array application problems. These effective tools facilitate more efficient support calls and faster problem resolution. The TS7700 Grid solution with the SAN42B-R Extension Switch offers the user a highly available, resilient mechanism for improving recovery point objectives (RPOs) and recovery time objectives (RTOs).

For more information

To learn more about the IBM TS7700 Grid and IBM SAN42B-R b-type Extension, please contact your IBM representative or IBM Business Partner, or visit the following websites:

- **ibm.com**/systems/storage/san/b-type/san42b-r/index.html
- **ibm.com**/systems/storage/tape/ts7700/index.html

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