Distance challenges of native array IP replication solutions

IBM b-type storage networking extension solutions overcome distance challenges

Enterprise data centers continue to be challenged with effectively managing the growing amount of data that has to be replicated between data centers for disaster recovery/business continuity (DR/BC). With the amount of data increasing rapidly, the type of workloads and application data that needs to be protected is expanding beyond Fibre Channel (FC)/FICON® block storage to include more business-critical IP-based storage—for both block-based and file-based data. Whereas a wide variety of IP replication solutions are available in the market, including a growing number of disk arrays and tape devices with native IP replication ports, these solutions are not optimized for replication over long distance. In a local or metropolitan environment, these replication solutions may deliver the needed performance and throughput to meet service levels and recovery objectives. However, when replicating over longer distance, these solutions have several inherent challenges that make it almost impossible to meet growing service level and recovery expectations. Such challenges include widespread replication throughput issues, network availability problems, and data security exposure.

For most enterprise organizations, replicating over distance is a key requirement to ensure adequate data protection for DR/BC. Replication throughput, however, must be at a level that enables the required recovery objectives to be met, regardless of the distance between data centers. Whereas meeting performance requirements at a local, campus, or even metro data center level can be achieved using native array IP replication solutions, these solutions are challenged to deliver the needed throughput over longer distances. With distance, these applications suffer major performance “droop,” a result of the effects of latency. In fact, testing shows that array native IP replication throughput dropped 44 percent compared to local replication application performance, with just 25 milliseconds (ms) latency (replicating between New York and Chicago, for instance).
This is due to latency alone. Beyond 25-millisecond latency, throughput dropped quite dramatically, making replication over longer distances using native array IP replication ports a nonviable solution for most enterprise organizations.

Another challenge for native array IP replication solutions is that IP WAN connections are notorious for being problematic. In addition to network latency, WAN connections experience frequent disruptions and events that have enormous implications for replication traffic. Issues such as dropped packets, jitter, degraded or complete loss of network connectivity, and competing demands for bandwidth from the user community all negatively impact replication applications, making it difficult to achieve availability and recovery objectives. As an example, when inserting just 0.1 percent packet loss (a rate that is common) into the New York to Chicago replication over distance test scenario described above, native array IP replication throughput dropped by 98 percent compared to local replication performance.1 These types of replication solutions were simply not designed to handle network interruptions. Keep in mind that each time a WAN link goes down, data in transit on the failed WAN link is lost, the replication application can time out and stop (including the I/O if performing synchronous replication), and the application goes into its restart/resync recovery mode. And with each restart or resync, replication falls further and further behind. With the ever growing amount of data that needs to be replicated and the very high replication speeds, even a small unplanned outage can take days to recover from and can result in unrecoverable data.

In addition, IP WAN connections typically involve multiple hops and often multiple service providers, making it complex and time-consuming to troubleshoot IP WAN problems.

Data security is another significant challenge for native array IP replication solutions. Some arrays encrypt data to provide protection for data-at-rest but often do not provide encryption for data in-flight. This means that after the data leaves the confines of the secure data center, critical data is unprotected, making it vulnerable to security breaches, data theft, and “man-in-the-middle” attacks. With the growing threats of hacking, snooping, and other high-profile cybercrimes, protecting data in-flight across the IP WAN is essential to meeting data security objectives. However, security cannot be performed at the expense of throughput. Some IP replication solutions do provide encryption of data in-flight as an option, but the performance penalty is significant—often reducing throughput by 30 to 70 percent.

IBM b-type storage networking extension solutions make use of 20 years of distance connectivity innovation and thought leadership to augment native IP replication solutions to overcome these critical challenges, helping enterprise IT meet its recovery and security objectives.

Overcoming distance challenges

The IBM System Storage SAN42B-R extension switch is a purpose-built, multiprotocol storage connectivity solution that brings enterprise-class extension benefits—previously available
only to FC/FICON storage—to IP storage replication, enabling new IP storage applications and new DR/BC architectures. Key IP storage features include:

- Local data center application throughput over unlimited distances
- Enhanced security with strong encryption for data in-flight, without a performance penalty
- Continuous availability with protection against WAN disruptions
- Simplified network management with greater control and insight

The SAN42B-R supports simultaneous FC, FICON and IP storage applications. It can consolidate and extend replication I/O from heterogeneous arrays and multiple protocols across the same managed tunnel, offering a comprehensive storage networking extension solution that integrates seamlessly into any IP network.

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**Figure 1.** Multimodality large-scale b-type storage networking extension deployment
**Accelerated performance over distance**

The SAN42B-R extension switch delivers outstanding scalability and throughput over distance, moving up to 50 times more data compared to native IP replication solutions.² This new level of performance over distance for IP storage applications enables use cases that were not previously feasible. In addition, with up to 80 gigabits per second (Gbps) of replication throughput per platform³—far greater than any other IP replication solution—the SAN42B-R also meets the requirements of large-scale deployments, providing concurrent support for multimodality environments (disk, tape, file, block, open systems, mainframe, and so on), as well as capacity for growth. Because it allows the consolidation of replication I/O across a single managed tunnel, the SAN42B-R negates the need for multiple extension technologies to support various applications within the data center and makes efficient use of shared network bandwidth. No other solution on the market provides this level of performance, scale, flexibility or cost-effectiveness.

To illustrate the point, consider the New York to Chicago replication example discussed previously. Instead of a 98 percent drop in throughput using the native IP replication solution with 25 millisecond latency and 0.1 percent packet loss, the SAN42B-R, with the same WAN connection, delivers throughput equivalent to that achieved locally within the data center. In fact, the SAN42B-R is able to maintain local data center replication throughput even across intercontinental distances. And IBM maintains local data center throughput even when 0.5 percent packet loss is added.⁴

The exceptional performance and scalability delivered by the SAN42B-R enables new ways to think about IP storage replication. With local data center performance over any distance, new IP storage capabilities are now available for your DR/BC infrastructure. Significant new distance applications can be deployed to meet availability and recovery objectives. New opportunities are available for consolidation and greater efficiencies, which share the WAN infrastructure between storage and non-storage applications.

To achieve this new level of performance for IP storage, the SAN42B-R incorporates several advanced technologies that are essential to ensuring maximum throughput and bandwidth use over distance:

- An aggressive TCP stack that is optimized for storage, called WAN-Optimized TCP (WO-TCP), a capability that is not available with solutions that use standard TCP stacks alone
- An advanced line-rate data compression architecture with three compression algorithms that are the most aggressive in the industry
- An encapsulation methodology that enables the industry's most efficient data transport across the WAN
- Protocol acceleration technology for open systems data replication, tape, and mainframe applications, which selectively apply optimization to all applications that can benefit in a consolidated, heterogeneous environment

These unique IBM b-type technologies combine to deliver industry-leading performance over distance. They are discussed in more detail in the Advanced technologies section of this paper.

**Enhanced security, continuous availability and simplified management**

Protecting data-at-rest within the data center—as is done with native IP replication solutions—is only a part of the challenge. After application data leaves the security of the data center and is replicated across an IP network, regardless of whether it uses the public Internet or private WAN connections, it becomes vulnerable to hackers and theft, exposing the organization to data breaches and unwanted publicity.
The SAN42B-R uses dedicated hardware to provide strong 256-bit advanced encryption standard (AES) encryption of data flows to protect data in-flight between data centers. By performing encryption at full line rate, data can be protected without impacting replication performance, ensuring that both security and throughput over distance requirements are met.

IBM b-type encryption technology is discussed in more detail in the Advanced technologies section of this paper.

Network disruptions and outages severely impact replication performance, making it difficult to achieve availability and recovery objectives. The IBM b-type storage networking portfolio offers a variety of unique technologies and capabilities that help overcome network interruptions and ensure continuous availability.

One unique technology is extension trunking. Typically, when a WAN link goes down, packets in transit on the failed link are lost, and the replication application stops and goes into error recovery mode. With extension trunking, availability is maintained by automatically retransmitting lost packets over a WAN link that was not affected, allowing the replication application to continue without disruption. Extension trunking is a key technology for enabling continuous availability.

Another critical and unique IBM b-type storage networking technology is adaptive rate limiting (ARL). When one extension switch becomes unavailable in a redundant pair, the bandwidth allocated to that device typically goes unused, resulting in only 50 percent of the bandwidth being available while the device is down. With ARL, the operating extension device automatically detects the idle device and dynamically adjusts to use 100 percent of the available WAN bandwidth, providing full throughput even during a failure. Without the ability to automatically adjust to WAN bandwidth changes—as is the case with array-based native IP ports—either too much or too little bandwidth causes subpar performance. ARL can also be used alongside non-storage applications to ensure that high-priority applications maintain their bandwidth during an outage, while lower priority applications sacrifice theirs. Also, if an IP path goes down, ARL works with extension trunking to optimally adjust the bandwidth usage based on the remaining path or paths.

The SAN42B-R is one component of an overall system that works together to help ensure continuous availability of the replication solution and to guard against disruption. Fabric Vision technology works with the SAN42B-R, providing threshold-based monitoring between data centers to automatically detect WAN issues and avoid unplanned downtime. With powerful built-in proactive monitoring, management, and diagnostic tools, organizations can get early warning of potential problems and minimize downtime with faster troubleshooting.

In addition, Fabric Vision technology and the SAN42B-R built-in traffic generator and WAN test tool allows organizations to pretest, validate, and troubleshoot the physical infrastructure, eliminating potential delays and downstream reliability issues for new deployments.

No other solution in the market offers this level of resiliency, availability, and control across the storage network. These key capabilities are discussed in more detail in the Advanced technologies section of this paper.

Monitoring a storage network is complex and requires advanced network expertise. It often involves manually collecting and compiling data from a variety of sources—a tedious and time-consuming task—and interpreting that data based on personal experience. Such is the case with native IP replication solutions. Without in-depth visibility and tools that take the “manual” effort out of network management, administrators spend too much time troubleshooting and not enough time planning for new initiatives.
Fabric Vision technology delivers unprecedented, real-time visibility and actionable insights into the storage network, helping organizations dramatically simplify management and reduce management costs. It does this by means of a variety of technologies, including the Monitoring and Alerting Policy Suite (MAPS), Flow Vision, and IBM Network Advisor.

With predefined groups, policies, rules and actions, and intuitive reporting capabilities, MAPS simplifies proactive, threshold-based monitoring and alerting of storage networks. Organizations that choose to customize their policies can do so quickly and easily, saving valuable time. In addition to streamlining deployment of proactive monitoring and alerting, MAPS delivers new levels of instrumentation and granularity, to fine-tune storage resources and accelerate troubleshooting and problem resolution.

Flow Vision works with MAPS to identify, non-disruptively monitor, and analyze the performance of specific data flows or frame types. Being able to visualize flows of interest through tunnels allows administrators to visualize specific applications, ensure that service levels are met, and simplify troubleshooting flow performance issues.

Fabric Vision technology is integrated into IBM Network Advisor, providing “out of the box” or customizable dashboard views that display the most critical storage network metrics on one screen—with drill-down capabilities to instantly view these and more:

- Real-time health and performance data and historical trends
- Out-of-compliance conditions, congestion, and latency concerns on flows
- The status of small form-factor pluggables (SFPs) and a variety of port-level error statistics

Together, Fabric Vision technology delivers real-time information that organizations can act on to meet availability and recovery objectives. It also integrates with third-party orchestration tools to provide holistic, end-to-end management of the storage network.

No other solution in the market offers this level of visibility, efficiency, and simplicity—driving down operational and capital costs.

**IBM System Storage SAN42B-R advanced technologies**

The SAN42B-R extension switch makes use of 20 years of distance connectivity innovation and thought leadership to deliver purpose-built, data center hardened extension platforms with a highly differentiated feature set.

All of the advanced technologies described below apply to FC, FICON, and IP storage replication solutions, enabling a consolidated, comprehensive storage extension solution that accelerates performance of all applications over distance, enhances security, reduces downtime, and simplifies management of the end-to-end storage network.

**WAN-optimized TCP**

TCP is essential to the high-speed transport of large data sets that are common in storage extension. WAN-optimized TCP (WO-TCP) optimizes TCP window size and flow control, accelerating TCP transport specifically for storage applications with heavy throughput. It also helps ensure full use of available bandwidth and maximum sustained throughput over the WAN. Regular TCP has exponential backoff and responds poorly to situations like packet loss over a WAN. (For example, it might interpret packet loss as congestion, in which case the standard response is exponential backoff. However, that is the wrong response when you are using a WAN connection and you have a high throughput workload that needs to get through.)
Often, native array IP replication solutions require WAN optimization products to deliver adequate application throughput over distance. WO-TCP is a transport that cannot be outperformed by competing WAN optimization products. In other words, you receive negligible benefits from additional WAN optimization when using the SAN42B-R extension switch. Overall, IBM b-type storage networking 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, are virtually the same compared to competing WAN optimization products, but an IBM b-type storage networking extension solution costs considerably less than WAN optimization products of comparable speed.

IBM b-type storage networking extension technology makes WAN optimization totally unnecessary for extension of Fibre Channel over IP (FCIP) and IP storage. In fact, adding WAN optimization to a b-type extension network introduces complexity, another point of failure, and another asset to configure, manage, monitor and troubleshoot. If WAN optimization already exists, SAN42B-R extension technology unnecessarily consumes that resource, which other non-storage applications should use instead.

WO-TCP integrates with ARL, and the synergy of these two technologies creates an industry-dominating transport for storage over long distances. No similar transport exists on any other IP extension or native array IP replication solution.

### Line-rate data compression

Specialized compression algorithms have been developed for the SAN42B-R. These algorithms vary in processing rate and compression ratio and are the most aggressive compression algorithms available in the industry. They cannot be found on any array-based native IP ports or competing products. See table 1.

IBM b-type storage networking IP extension offers two compression algorithms; deflate and aggressive deflate, and provides up to 32 Gbps of ingress throughput per platform using deflate compression. Depending upon the compressibility of the data, the WAN bandwidth required is reduced accordingly.

### Line-rate data encryption

Brocade has developed Hardware-based Internet Protocol security (IPsec) for secure data in-flight across extension inter-switch links (ISLs) has also been developed. 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), 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 per tunnel and trunk on each side.

<table>
<thead>
<tr>
<th>Platform configuration</th>
<th>Max. FC application throughput</th>
<th>Max. IP application throughput</th>
<th>Max. IP+ FC application throughput</th>
<th>Max. WAN throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAN42B-R Base</td>
<td>20 Gbps - Aggressive deflate</td>
<td>20 Gbps - Aggressive deflate</td>
<td>20 Gbps - Aggressive deflate</td>
<td>5 Gbps</td>
</tr>
<tr>
<td>SAN42B-R Base + Upgrade #1 (FC 2171)</td>
<td>30 Gbps - Deflate</td>
<td>30 Gbps - Deflate</td>
<td>30 Gbps - Deflate</td>
<td>10 Gbps</td>
</tr>
<tr>
<td>SAN42B-R Base + Upgrades #1 and #2 (FC 2171 + FC 2172)</td>
<td>80 Gbps - Fast deflate</td>
<td>32 Gbps - Deflate</td>
<td>40 Gbps FC - Fast Deflate</td>
<td>20 Gbps (or 40 Gbps for FC only with Fast deflate or IP-only uncompressed)</td>
</tr>
</tbody>
</table>

*Table 1. IBM b-type storage networking IP extension compression*
Best practice is to use IPsec for extension, both FCIP and IPEX (IP extension). IPsec is part of circuit formation and protects data from virtually every type of attack, including sniffers, data modification, identity spoofing, man-in-the-middle, and denial of service attacks.

IPsec requires no additional licenses or costs and is simple to configure. IPsec plus extension trunking gives you 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. This is a large amount of encrypted load balanced data bandwidth (up to 40 Gbps) for a single box. IPsec provides prudent security for most organizations and is provided at no additional cost with the SAN42B-R.

Efficient encapsulation methodology

**FCIP encapsulation**

To create the maximum payload per unit of overhead, SAN42B-R uses a unique method of forming streams of bytes from storage I/O. There is no concept of individual FC frame discrete encapsulation, which would be too inefficient (yet is used by many competing products). IBM SAN42B-R forms a stream of bytes, which is transported by WO-TCP. Sixteen data frames form a stream called a “batch.” Each batch has a single extension header, which reduces headers by 16:1. The batch is then compressed. By compressing the entire batch, it is possible to gain higher compression ratios. Various deflate-based compression algorithms have been developed, namely fast deflate, deflate, and aggressive deflate to gain these higher compression ratios. Each algorithm has a different trade-off of speed versus compression ratio. The stream fills TCP segments to their maximum segment size. The maximum segment size is the IP maximum transmission unit (MTU) minus the IP and TCP headers (IP + TCP headers totals about 40 bytes). The result is full-size IP datagrams and minimal overhead, no matter what the compression is. Relative to other competing replication transports, the SAN42B-R FCIP encapsulation method excels in efficiency.

**IP encapsulation**

When LAN TCP/IP traffic is run through the IP extension switch, the LAN TCP sessions are proxied (terminated locally), resulting in two TCP connections being created. One TCP connection is created between the local storage array and the local extension device; another is created between the remote extension device and the remote storage array. By doing this, incoming LAN TCP/IP traffic is stripped of all network headers (Ethernet/IP/TCP), leaving only the data behind for transport across the WAN. The data frames are batched together, and then transported across the WAN using WO-TCP. This process minimizes the protocol overhead imposed by the IP extension solution. It also allows the use of jumbo frames on the WAN, even if the storage application does not support jumbo frames. This is made possible by the fact that the batches are sent across the WAN in jumbo-sized Ethernet frames and are then broken up into standard-sized Ethernet frames by the remote extension device, presenting standard MTU frames to the remote storage array. This process allows the fastest possible communications from the end IP storage devices and the SAN42B-R by local fiber connections within the data center. WO-TCP is a data transport that has no comparison to IP storage end devices. No competing replication transport is as efficient or performs as well as the IP encapsulation method with WO-TCP.

**Protocol optimization**

When using extension devices external to storage arrays, combining other storage applications such as tape, mainframe, and file-based data over the same tunnel (one VE_Port) or different tunnels (different VE_Ports) is highly efficient and cost-effective. The IBM b-type storage networking extension switch has protocol optimization for Open Systems Tape Pipelining (OSTP) read/write and FICON Acceleration, such as XRC, tape read/write, and Teradata. It can support optimization of all of these protocols simultaneously. The IBM b-type storage networking extension switch can discern these different applications and apply protocol optimization to those that can benefit. These applications can be extended great distances, mitigating the effects of latency while maintaining full bandwidth utilization.
Extension trunking
With extension trunking, each storage I/O session accesses all the WAN bandwidth that is seen by all the circuits belonging to a tunnel. An extension tunnel is defined by its VE_Port endpoint. The tunnel has a maximum bandwidth of 20 Gbps on the SAN42B-R extension switch.

Having multiple circuits per tunnel enables high availability. Extension trunking spreads data across all circuits, and those circuits can be dispersed across various paths and service providers; there is no requirement for equal bandwidth or latency among the circuits. This capability, combined with the ability to failover or failback without data loss or out-of-order data, is essential for mainframe environments and makes for more durable open system RDR environments, as well.

If an IP path goes down at any level, such as service provider, local or remote, switches or routers, optics, cables, and so on and circuits are dispersed across different service providers, routers, switches and paths no outage occurs, provided at least one path remains up. Adaptive rate limiting (ARL) optimally readjusts the bandwidth usage based on the remaining path or paths.

Extension trunking is lossless. No data is lost, and all data is received by the upper layer protocols (ULP) in-order. The storage applications do not time out and do not perform error recovery, ensuring continuous operation.

Adaptive rate limiting
Where rate limiting occurs in the network is important, and that point is after storage flows have been aggregated and before the IP WAN. IBM SAN42B-R extension switch should be connected as close to the WAN as possible. This way, the aggregate of all data flows is managed holistically with security and QoS effectively applied.

Array “auto-adjust” rate limiting pertains to just the array itself. More than one array renders auto-adjust rate limiting ineffective. Moreover, auto-adjust rate limiting cannot take into account changes occurring in the WAN. As an example, consider a degraded situation in which a primary OC-192 (10 Gbps) goes offline and is backed up by two secondary OC-48s (5 Gbps) that are shared with non-storage applications. There is no way for array auto-adjust rate limiting to compensate for this outage. The overall bandwidth has been reduced in half, forcing the native IP ports to use TCP flow control to manage the inevitable congestion. TCP does not efficiently manage flow control while providing performance, and the result is poor storage throughput, which is worse than the bandwidth outage itself.

This is not the case with the SAN42B-R extension switch ARL feature. ARL automatically adjusts the rate limiting on all associated circuits replicating across the IP WAN, regardless of the ingress FC or IP device and the WAN path or paths. ARL automatically adjusts rate limiting when other IBM extension circuits go online or offline or the available IP WAN bandwidth experiences changes. ARL works across all IBM b-type storage networking extension products and uses the same WAN infrastructure.

Shared WAN connections with non-storage applications are common. ARL is designed to work on WAN connections that are shared with other IP storage and non-storage applications. Array auto-adjust rate limiting was not designed for such instances. In fact, the SAN42B-R can be configured so that during an outage, high-priority applications maintain their bandwidth while lower-priority devices sacrifice theirs. 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 uses the available bandwidth while maintaining nonstop operations.
ARL is a function of high importance for optimal operation. If auto-adjust rate limiting on array-based native IP ports cannot efficiently adapt to changes in WAN bandwidth, either too much rate or too little rate causes non-optimal performance. Consider how constantly varying workloads make it impractical to tune individual arrays. Additionally, LUN/volumes cannot practically be relocated to remedy the array auto-adjust rate limiting problem. Dedicating WAN bandwidth to specific array native IP ports causes imbalanced issues. The only answer is to locate ARL downstream from the arrays.

Fabric Vision technology
Fabric Vision technology offers a number of tools that position it as the leader in its field. Some of these features are detailed in the sections that follow.

Monitoring and alerting policy suite
IBM customers ask, “How can we resolve support issues more quickly and effectively?” “How do we resolve issues before they become critical and before the RDR application goes down?” The situation is further aggravated by the inability to quickly pinpoint whether the problem is a network issue or a storage issue. Customers are greatly interested in the ability provided by IBM through the b-type storage networking portfolio to proactively monitor and effectively troubleshoot the local storage connections and network device health—as well as the ability of the IP WAN to meet its SLA.

It is important to build intelligence into these networking systems. When a data connection starts to experience errors of any kind, the proper action might not be readily apparent until the situation becomes a major outage. Given the large permutation of possible errors and effects, years of practical experience is required. The SAN42B-R provides operational excellence by making use of 20 years of extension experience, both in open systems and mainframe. Monitoring and alerting policy suite (MAPS)—is a key element of Fabric Vision technology—for b-type Fabric OS (Brocade FOS) and IBM Network Advisor, meant to provide a comprehensive suite of monitors, alerts, actions and reporting of storage networks. MAPS assists operations in achieving higher availability, quicker troubleshooting, and infrastructure planning. It provides a prebuilt, policy-based threshold monitoring and alerting tool that proactively monitors the storage extension network health, based on a comprehensive set of metrics at tunnel, circuit, and QoS layers. Administrators can configure multiple fabrics at one time using predefined or customized rules and policies for specific ports or switch elements.

MAPS monitors use, packet loss, RTT, jitter, and state changes for tunnels and trunks, circuits, and Per-Priority-TCP-QoS (PTQ). Each PTQ priority (class-F, low, medium, or high) is monitored independently and includes throughput, duplicate acknowledgments (ACKs), packet count, packet loss, and slow-starts.

MAPS can be used in many situations. One example is the fencing of circuits that exhibit errors. MAPS is 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. This type of configuration, monitoring, reporting, and diagnosis system is not available on any other IP replication or extension solution.

Flow Vision
Visualization of flows through tunnels is another important capability of the SAN42B-R. Not all flows are created equal, and a tunnel managed by b-type storage networking technology allows administrators to centrally visualize each application. Storage administrators monitor network and flow behavior to ensure that SLAs are met. This is difficult to accomplish if managed from each originating device and port.

Troubleshooting network flows is often a difficult and daunting endeavor. Making matters more difficult, storage administrators are not familiar with IP networks, and IP network administrators are not familiar with storage. These two groups have 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.

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 there is nothing wrong with the network, and flows fall victim to perpetrators. Perpetrator flows are flows that use excessive resources to the point that other flows fall victim. This frequently happens downstream from the storage handoff to the IP WAN. IBM b-type storage networking FC, FICON and extension switches provide features, functionality, and tools to deal with storage SLAs. Flows within the protection of extension tunnels meet their SLAs when they come up against perpetrator flows.

Flow Vision, a key element of Fabric Vision technology, enables administrators to identify, monitor, and analyze specific application flows to simplify troubleshooting, maximize performance, avoid congestion, and optimize resources. The SAN42B-R has the capability to monitor specific LUN flows between F_Ports that are communicating end-to-end across the extension network. It is also possible to monitor flows coming in from an E_Port. At LUN level granularity, I/O operations per second (IOPS) and data rate can be monitored.

Flow Vision includes the following features:

- Flow monitor: This provides comprehensive visibility into flows across storage extension networks, including the ability to automatically learn flows and nondisruptively monitor flow performance. Administrators can monitor all flows from a specific storage device that are writing to or reading from a destination storage device or LUN, or across a storage extension network. Additionally, administrators can perform LUN-level monitoring of specific frame types to identify resource contention or congestion that is affecting application performance.

- Flow generator: This is a built-in traffic generator for pretesting and validating storage extension infrastructure— including route verification, QoS zone setup, extension trunking configuration, WAN access, IPsec policy setting, and integrity of optics, cables, and ports—for robustness, before deploying applications.

For more information on Fabric Vision technology, please visit: [ibm.com/systems/storage/san/b-type/fv/index.html](http://ibm.com/systems/storage/san/b-type/fv/index.html)

**WAN test tool (Wtool)**

Wtool was introduced with the SAN42B-R and accurately tests multiple IP network paths. Wtool generates traffic at specified rates between a pair of IP addresses. Wtool reports achieved throughputs, jitter, experienced latencies, congestion, packet losses, and network reordering. Wtool supports pertinent circuit characteristics, including Path MTU (PMTU), VLAN tagging, IPv4/IPv6, IPsec, and jumbo frames. The main purpose of Wtool is to validate the IP network before deploying a circuit. It is also useful as a diagnostics tool when you encounter a reliability issue with a circuit.

Wtool simulates extension traffic in exactly the way that the IP network sees it, such that the test results are truly relevant. Wtool runs in the background and allows multiple simultaneous test sessions to coexist, up to eight sessions (four sessions per DP). Each test session equates to a single circuit. The total concurrent test capacity is eight circuits or two fully loaded tunnels/trunks. These connections are a user datagram protocol (UDP)-like simulation to facilitate detection of congestion, out-of-order delivery, and packet loss. However, Wtool runs the same TCP as the circuits do, so that IP network security mechanisms do not prevent testing, and IP network security devices are tested also.
Summary
IBM b-type storage networking extension solutions make use of 20 years of distance connectivity innovation to deliver purpose-built, data center hardened extension platforms with a unique set of features to overcome the challenges faced by native array IP replication solutions and help enterprise IT achieve its data availability and recovery objectives:

- Maximum throughput over any distance
- Security for data in-flight, without a performance penalty
- Continuous availability
- Network visibility with consolidated control
- Simplified management

Regardless of protocol (FC, FICON, IP, or any combination), IBM b-type storage networking extension solutions offer the fastest, most reliable, and most cost-effective network infrastructure for consolidated, highly scalable, multisite data center environments implementing data replication over distance solutions.

Take control of DR/BC with IBM b-type storage networking extension solutions for IP, FC, and FICON storage.

For more information
To learn more about distance challenges of native array IP replication solutions, please contact your IBM representative or IBM Business Partner, or visit the following website:
ibm.com/systems/storage/san/b-type/san42b-r/index.html

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1 IBM Technical white paper, “Enhanced Resilient Solutions for Business Continuity” http://ibm.co/1ThYB0R

2 ibid

3 ibid

4 ibid