

Brocade[®] Fabric OS Product Family

GEN 6 FIBRE CHANNEL

Brocade Gen 6 Fibre Channel is the purpose-built network infrastructure for mission-critical storage, delivering breakthrough performance, increased business agility, and operational stability. Brocade Fabric Vision[®] technology with IO Insight, VM Insight, and Gen 6 Fibre Channel provides a breakthrough hardware and software solution that helps accelerate data access, adapts to evolving requirements, and drives always-on business operations for hyper-scale virtualization, larger cloud infrastructures, and growing flash-based storage environments.

Gain Control and Insight for the Next-Generation Data Center

The use of virtualization, flash storage, and automation tools has allowed applications and services to be deployed faster while shattering performance barriers. The unprecedented number of application and service interactions has also increased the complexity, risk, and instability of mission-critical operations. As a result, IT organizations need flexible storage networks that can adapt to dynamic environments and performance requirements for high-density virtualization, flash storage, and cloud infrastructures. To meet Service Level Agreement (SLA) objectives, IT administrators also need new tools that can help ensure non-stop operations, quickly identify potential points of congestion, and maximize application performance, while simplifying administration.

As a leading provider of data center networking solutions, Brocade, A Broadcom Inc. Company, helps organizations around the world connect, share, and manage their information in the most efficient manner. Organizations that use Brocade products and services are better able to ensure SLAs, optimize their IT infrastructures for always-on operations, and reduce costs by simplifying administration.

This guide summarizes the Brocade Fabric OS[®] (FOS) product family and the innovative features that make Brocade the leading choice in performance, instrumentation, quality, and cost. It includes:

- Brocade FOS product family overview
- Brocade core technology overview
- Brocade Fabric Vision technology
- Fabric automation
- Additional RAS features
- Brocade Storage Area Network (SAN) Fabric technology overview
- Additional Brocade resources

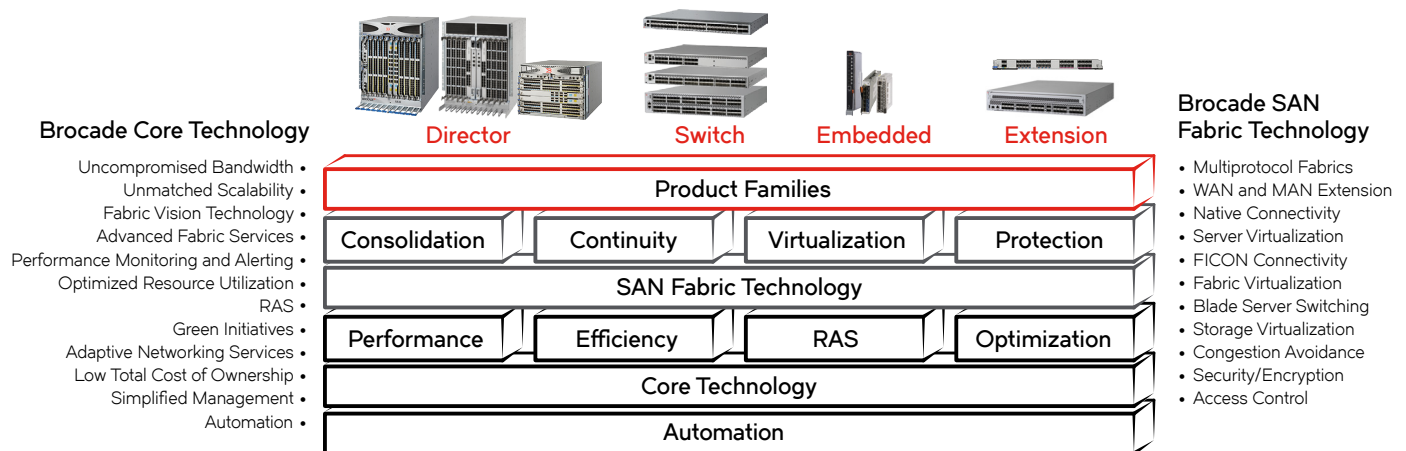


Figure 1: Brocade product and technology overview.

Brocade FOS Product Overview

The Brocade FOS family includes a wide range of industry-leading products, including:

- **Directors:** The Brocade X6 Director features industry-leading Gen 6 Fibre Channel that increases performance for demanding workloads across 32 Gbps line-speed links and up to 16.2 Tbps of chassis bandwidth to address next-generation I/O- and bandwidth-intensive applications. Gen 6 Fibre Channel technology provides up to 566 million frames switched per second per ASIC, allowing the Brocade X6 Director to achieve up to 1 billion IOPS, unlocking the full capability of flash storage. This breakthrough performance speeds up data-intensive application response times, allows more transactions in less time, and enables improved SLAs. In addition, the Brocade X6 Director increases scalability with double the throughput for high-density VM deployments and larger fabrics. This allows administrators to support more storage devices and meet bandwidth requirements using the same number of Fibre Channel links.

- **Switches:** Brocade G610, G620, and G630 Switches are designed to meet the demands of hyper-scale virtualization, large cloud infrastructures, and growing flash-based storage environments by delivering market-leading Gen 6 Fibre Channel technology. Brocade Gen 6 Fibre Channel is the purpose-built, data center-proven network infrastructure for mission-critical storage, delivering breakthrough 32 Gbps performance, unmatched reliability, and operational stability to accelerate data access, adapt to evolving requirements, and drive always-on business. These high-performance, highly reliable Fibre Channel switches address a wide range of business requirements, for small shared storage environments all the way up to the most demanding enterprise data centers.

- **Embedded switches:** Brocade embedded switches are designed to meet the unique and demanding requirements of the blade server market. These products can operate in Brocade Access Gateway mode, increasing scalability and simplifying management since the embedded switch does not appear as a traditional fabric switch.

- **Extension solutions:** Brocade provides purpose-built data center extension solutions for Fibre Channel and IP storage environments. These extension solutions are designed for high-speed, secure transport of data between data centers while maintaining uptime. They enable storage and mainframe administrators to optimize and manage the use of WAN bandwidth, secure data over distance, and minimize the impact of disruptions to help ensure objectives are met.

Brocade Core Technology Overview

All Brocade products are based on a foundation of innovative, industry-leading core technologies that help improve performance, efficiency, RAS, and optimization at an affordable cost. Brocade created the first Fibre Channel switching products, and continues to lead the development of Fibre Channel standards, offering breakthrough Gen 6 Fibre Channel products and innovative Brocade Fabric Vision technology.

Table 1: Brocade switching product scalability.

Product Family	Chassis/Switch Bandwidth (data rate)	Slot Bandwidth (data rate)	Port Speeds (Gbps)	Ports
Director	Up to 20.2 Tbps	1.5 Tbps	4, 8, 10, 16, 32	48 to 512 and 32 ICL ports
Switch	Up to 4 Tbps	N/A	4, 8, 10, 16, 32	48 to 128
Embedded	Up to 384 Gbps	N/A	1, 2, 4, 8, 16	12 to 24

Note: No embedded product for Gen 6 available at this time.

Performance

Fibre Channel SAN fabrics have the most stringent performance requirements of any network technology. They must have low latency and guaranteed delivery while supporting growing workloads and accommodating bursts in application data flows without disrupting applications—capabilities provided by the Brocade FOS family of products.

Bandwidth

Switching products must have enough bandwidth to avoid congestion for all data traffic. Brocade provides a wide range of price/performance options so organizations can choose the right solutions for their unique business requirements. Brocade director products provide both core switch engines and port switch engines, or local switching. This capability boosts performance for high-bandwidth applications.

Scalability

Because fabric traffic increases as storage and server connections grow, a fabric must provide excellent scalability. In turn, switching bandwidth must be large enough to meet the combined requirements of thousands of applications simultaneously. Table 1 shows key scalability metrics for the Brocade switching product categories.

Efficiency

Data center efficiency has become essential for organizations that must manage data growth within their existing power, cooling, and floor space constraints. Brocade is at the forefront of innovative data center efficiency, driving energy use down to 0.26 watts per Gbps for Brocade X6 Directors with Gen 6 Fibre Channel and as low as 0.10 watts per Gbps for Brocade Gen 6 Fibre Channel switching products.

Utilization

Maintaining high fabric resource utilization is paramount to implementing green technology initiatives and achieving a low Total Cost of Ownership (TCO). The following features help increase resource utilization:

- **Frame-based trunking:** Data flows are automatically distributed over multiple physical Inter-Switch Link (ISL) connections and logically combined into a trunk to provide full bandwidth utilization while reducing congestion.
- **Exchange-based trunking with Dynamic Path Selection (DPS):** For long-distance links between data centers over xWDM or WANs, exchange-based trunking provides high utilization to accommodate the larger latencies common over MAN and WAN distances.

- **Connection-based load balancing with Dynamic Link Selection (DLS):** This feature monitors link or trunk utilization to ensure load balancing. DLS can be used with either frame-based or exchange-based trunking when multiple trunks or ISLs are available between two switches.

- **Fibre Channel Routing Inter-Fabric Links (IFLs):** Fibre Channel Routing ensures the highest utilization of IFLs, which route traffic between fabrics. IFL trunking logically groups multiple links into a single high-bandwidth trunk to ensure efficient bandwidth utilization between individual fabrics and Fibre Channel routers.

Reliability, Availability, and Serviceability (RAS)

RAS describes several features of a product's design that affect its reliability (failure incidence), availability (uptime), and serviceability (ease of fault isolation and service). The Brocade FOS product family offers advanced capabilities to deliver unmatched reliability, availability, and management simplicity.

Brocade Fabric Vision Technology

Brocade Fabric Vision technology with VM Insight and IO Insight is an extension of Gen 6 Fibre Channel, including NVMe over Fibre Channel. It provides unprecedented insight and visibility across the storage network with powerful, integrated monitoring, management, and diagnostic tools that enable organizations to:

Simplify monitoring:

- Deploy more than 20 years of storage networking best practices in predefined, threshold-based rules, actions, and policies with a single click
- Take advantage of non-intrusive, real-time monitoring and alerting of SCSI or NVMe storage IO health and performance with key latency and performance metrics
- Leverage integrated network sensors to gain visibility into VM and storage IO health and performance metrics to maintain SLA compliance
- Gain comprehensive visibility into the fabric through browser-accessible dashboards with drill-down capabilities to easily identify network health, performance, latency, and congestion issues

Increase operational stability:

- Avoid 50 percent of common network problems with proactive monitoring and advanced diagnostic tools that address problems before they impact operations
- Identify hot spots and automatically mitigate network problems—before they impact application performance—through intuitive reporting, trend analysis, and integrated actions
- Monitor and set baselines on IO latency for each VM, and identify performance anomalies to facilitate fault isolation and troubleshooting

- Pinpoint resource contention, congestion, and errant devices to resolve application performance problems

Dramatically reduce costs:

- Eliminate nearly 50 percent of maintenance costs through automated testing and diagnostic tools that validate the health, reliability, and performance of the network prior to deployment
- Save up to millions of dollars on CapEx costs by eliminating the need for expensive third-party tools through integrated network sensors, monitoring, and diagnostics
- Leverage specialized tools for pretesting and validating IT infrastructure to accelerate deployment, simplify support, and reduce operational costs
- Tune device configurations with integrated IO metrics to optimize storage performance and increase ROI

Monitoring and Alerting Policy Suite

Monitoring and Alerting Policy Suite, or MAPS, provides an easy-to-use solution for policy-based threshold monitoring and alerting. It proactively monitors the health and performance of any SCSI or NVMe storage infrastructure to ensure application uptime and availability. By leveraging prebuilt rule-/policy-based templates, MAPS simplifies fabric-wide threshold configuration, monitoring, and alerting. Administrators can configure the entire fabric (or multiple fabrics) at one time using common rules and policies, or customize policies for specific ports or switch elements. With Flow Vision and VM Insight, administrators set thresholds for VM flow metrics in MAPS policies in order to be notified of VM performance degradation.

Brocade ClearLink Diagnostics

Organizations can use this Fabric Vision technology tool to ensure optical and signal integrity for Fibre Channel optics and cables, simplifying deployment and support of high-performance fabrics. ClearLink® Diagnostic Port (D_Port) is an advanced capability of Fibre Channel platforms. Non-Brocade devices require the Fabric Vision technology license.

Flow Vision

Flow Vision enables administrators to identify, monitor, and analyze specific application flows in order to simplify troubleshooting, maximize performance, avoid congestion, and optimize resources. Flow Vision includes

- **Flow Monitor:** Provides comprehensive visibility, automatic learning, and non-disruptive monitoring of a flow's performance. Administrators can monitor all flows from a specific host to multiple targets or volumes, from multiple hosts to a specific target/volume, or across a specific ISL. Additionally, they can perform volume-level monitoring of specific frame types to identify resource contention or congestion that is impacting application performance. With the IO Insight capability, administrators can monitor first IO response time, IO completion time, the number of pending IOs, and IOPS metrics for a flow from a specific host to a target or volume running SCSI or NVMe over Fibre Channel traffic. With VM Insight, administrators can monitor network throughput and IO statistics for each VM.
- **Flow Learning:** Enables administrators to non-disruptively discover all flows that go to or come from a specific host port or a storage port, or traverse ISLs/IFLs or FCIP tunnels, to monitor fabric-wide application performance. In addition, administrators can discover top and bottom bandwidth-consuming devices and manage capacity planning.

- **Flow Generator:** Provides a built-in traffic generator for pretesting and validating the data center infrastructure for robustness—including route verification and integrity of optics, cables, ports, back-end connections, and ISLs—before deploying applications.
- **Flow Mirroring:** Enables administrators to non-disruptively create copies of specific application and data flows or frame types that can be captured for in-depth analysis. It also provides vTap support to mirror flow statistics remotely to an ASL-connected Brocade Analytics Monitoring Platform.

IO Insight

IO Insight proactively monitors IO performance and behavior through integrated network sensors to gain deep insight into problems and ensure service levels. This capability non-disruptively and non-intrusively gathers IO statistics for both SCSI and NVMe traffic from any device port on a Gen 6 Fibre Channel platform, then applies this information within an intuitive, policy-based monitoring and alerting suite to configure thresholds and alarms. Integrated application- and device-level IO latency and IOPS monitoring provides the ability to baseline application performance and detect degraded performance. This enables administrators to proactively control performance and availability to ensure operational stability. Key capabilities include:

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

- Enables tuning of device configurations with integrated IO metrics to optimize storage performance

VM Insight

VM Insight seamlessly monitors VM performance throughout a storage fabric with standards-based, end-to-end VM tagging. Administrators can quickly determine the source of VM/application performance anomalies, as well as provision and fine-tune the infrastructure based on VM/application requirements to meet service-level objectives.

Fabric Performance Impact Monitoring

Fabric Performance Impact (FPI) Monitoring leverages predefined MAPS policies to automatically detect and alert administrators to different latency severity levels, and to identify slow drain devices that could impact network performance. This feature identifies various latency severity levels, pinpointing exactly which devices are causing or are impacted by a bottlenecked port, and quarantines slow drain devices automatically to prevent buffer credit starvation.

Critical Monitoring, Management, and Diagnostics

Fabric Vision technology includes several critical monitoring, management, and diagnostic capabilities that help to increase fabric resiliency, reduce downtime, and optimize application performance. The following features are included in base Brocade FOS releases:

- **Brocade ClearLink Diagnostics:** Helps ensure optical and signal integrity for Fibre Channel optics and cables, simplifying deployment and support of high-performance fabrics. ClearLink Diagnostic Port (D_Port) is an advanced capability of Fibre Channel platforms. Non-Brocade devices require the Fabric Vision technology license.

- **Forward Error Correction (FEC):** Enables recovery from bit errors in Gen 5 links, enhancing transmission reliability and performance. FEC is mandatory when using Gen 6 links in order to maximize the reliability of 32 Gbps performance.
- **Credit Loss Recovery:** Automatically detects and recovers buffer credit loss at the Virtual Channel (VC) level, providing protection against performance degradation and enhancing application availability.
- **MAPS Basic Monitoring:** Monitors system resources, FRU status, FPI, and overall switch health status through MAPS basic monitoring policy. Slow drain device quarantine action with FPI monitoring requires the Fabric Vision technology license.

Additional RAS Features

The Brocade FOS product family offers additional advanced features that help ensure the highest level of reliability, availability, and serviceability. They include:

- **Hot-code load/activation:** This ensures that firmware updates applied to fabric devices do not disrupt data flowing between applications and storage.
- **Auto daemon restart:** The embedded operating system used in Brocade products is strengthened with automated task restart features for increased reliability and availability.
- **Port fencing:** This feature tracks errors and events on a port against a specified threshold. When the threshold is exceeded, the port is turned off to prevent it from endangering other traffic in the fabric.
- **Port decommissioning:** This feature provides the ability to non-disruptively remove an ISL from service.
- **FCping/FC trace route:** These tracking features confirm that ports and paths are operational, and that latencies between ports are within expected limits.

- **RAS event logging with NTP server:** Messages about events that impact RAS can be forwarded to a central collection point with synchronized time stamps provided by a central Network Time Protocol (NTP) server.
- **Change auditing:** This feature logs all changes in the fabric and forwards the change event logs to centralized Syslog and Secure Syslog servers to improve management control and security.

Fabric Automation

IT organizations spend nearly half of their time performing repetitive daily management tasks, such as zoning, inventory reporting, and operational validation checks. By automating these repetitive tasks, IT organizations can significantly improve their efficiency and dramatically decrease the risk of operational mistakes. Automation in large-scale IT environments integrates diverse infrastructure components with consistency and predictability to deliver greater operational efficiency and agility. With more than 20 years of storage networking experience, Brocade understands the nuances that go into infrastructure management and the tasks that can benefit from automation. By introducing REST APIs directly into its switch and management products, Brocade offers a broad range of choices to enable any SAN management solution. IT organizations that couple Brocade's robust data collecting capabilities with automation and orchestration tools (such as Ansible) gain the ability to automate configuration tasks and the visibility to monitor and detect any performance or health changes.

Brocade automation solutions are based on these pillars:

- Make standard REST APIs available directly from the switch in order to automate repetitive daily tasks, such as fabric inventory, provisioning, and operational state monitoring.
- Quickly integrate systems with open source PyFOS, a Python language, to simplify common SAN management practices.
- Leverage Ansible to easily scale automation and orchestration across the entire infrastructure.

Management Simplicity

Fabric configuration and management can become increasingly time-consuming and complex as fabric size grows. To address these challenges, Brocade offers the following features:

- **Integration with Brocade Network Advisor:** Offers a single point of management, with customizable health and performance dashboard views to pinpoint problems faster, simplify SAN configuration and management, and reduce operational costs.
- **Fabric-Assigned World Wide Name (FA-WWN):** Allows organizations to eliminate fabric reconfiguration when adding or replacing servers through the virtualization of host World Wide Names (WWNs). FA-WWN also enables configuration of servers before they are available, accelerating deployments.
- **Insistent Domain ID:** Ensures that switch addresses are reserved and not changed when switches are added or removed from a fabric.
- **Registered State Change Notification (RSCN) suppression:** Ensures that RSCN messages are sent only to devices requiring notification of a fabric event, reducing bandwidth and processor cycle consumption.

- **Link Cable Beacon:** Provides LED beaconing for ports on both ends of a physical link to simplify cable identification and management.
- **Read Diagnostic Parameter:** Allows diagnosis of transceiver and media problems for a link in a fabric from a single point, either a switch or a host.
- **Port speed-weighted Fabric Shortest Path First (FSPF):** Applies a weighting factor based on link speed to ensure that data traffic uses higher-speed paths between switches.
- **Fabric Device Management Interface (FDMI):** Enables Brocade Network Advisor to manage switch configuration, simplifying end-to-end fabric management.
- **Time Server support:** Synchronizes all time stamps either to a principal switch in a fabric or to a central Network Time Protocol (NTP) time server for uniform event correlation, simplifying fault isolation.
- **SNMP MIBs:** Supports Simple Network Management Protocol (SNMP) v1 and v3 for fabric monitoring and management, and Brocade also publishes a Management Information Base (MIB) for all products.
- **IPv6 addressing:** Enables full addressing flexibility, including IPv4 and IPv6 dual stack support for management traffic.
- **DHCP/DHCPv6:** Supports automatic IPv4 and IPv6 address assignments to Gen 6 directors and switches.
- **Integrated device and fabric management:** Features an integrated management suite—Brocade Network Advisor—that centralizes device management as well as fabric configuration for the zoning and routing of all Brocade products.

- **Simple switch configuration:** Provides the EZSwitchSetup wizard (Microsoft Simple SAN-certified) to significantly simplify switch configuration and setup.
- **Dynamic Ports on Demand (PoD):** Activates specific switch ports only when growth dictates the need for more ports. Dynamic PoD enables switches to automatically use any activated switch port rather than specific ports, simplifying switch and blade server configuration.
- **Enhanced zoning services:** Enables zoning to configure peer zones, target-driven peer zones, Fibre Channel Routing services, Traffic Isolation, Quality of Service (QoS), and Frame Redirection.
- **Dynamic port name:** Assigns a switch port name automatically and dynamically based on a predefined or user-configured template and port type.

Brocade SAN Fabric Technology Overview

The Brocade Gen 6 Fibre Channel SAN fabric technology strategy is based on meeting real-world requirements for next-generation data centers. The key drivers of this strategy include higher levels of consolidation, continuity, virtualization, and data protection.

Consolidation

Data growth and relentless cost reduction are fueling an unprecedented drive for consolidation in the data center. To support this need, Brocade delivers key technologies for consolidation—including multiprotocol support, native connectivity, FICON and blade server connectivity, congestion control, and innovative bandwidth aggregation such as that used in backbone UltraScale Inter-Chassis Links (ICLs).

Multiprotocol Support

Fibre Channel is the underlying technology in most SAN fabrics, supporting both open systems SCSI channels (FCP) and System z mainframe channels (FICON). To meet a broad spectrum of customer requirements, Brocade protocol support includes Fibre Channel over IP (FCIP) and Fibre Channel Routing. In addition, Brocade FOS supports IP storage extension within the Brocade 7840 Extension Switch and Brocade X6 Directors.

FICON Connectivity

Fibre Channel supports a variety of “upper-layer protocols” such as FICON used in IBM System z environments. Brocade has partnered with IBM to create high-integrity fabric characteristics for System z environments, including:

- **FICON cascading:** Developed jointly by Brocade and IBM to extend System z environments to one-hop configurations, FICON cascading helps increase fabric scalability without sacrificing critical FICON channel performance.
- **FICON intermix:** Brocade, in collaboration with IBM, provides a FICON intermix solution that combines FICON and FCP traffic in the same fabric for greater resource utilization.
- **FICON Management Server (CUP):** Brocade was the first switch vendor to provide FICON Management Server—Control Unit Port (CUP)—so mainframe-hosted tools could manage connectivity between ports, monitor fabric performance, and collect critical diagnostic information.
- **System z mainframe innovations:** Brocade was the first vendor to provide FICON-capable switches, and the first with secure fabrics utilizing the DH-CHAP authentication protocol.

Blade Server Connectivity in Brocade Access Gateway Mode

Blade servers are provided by most of the leading server vendors (Dell, Fujitsu, HP, Hitachi, Huawei, IBM, and others), and they include embedded switches. Because these switches have low port counts, the number of switches (domains) in a fabric increases quickly and can limit fabric size. Brocade has addressed this issue with Brocade Access Gateway mode, which eliminates the switch address for an embedded switch. Key features include:

- **Auto port configuration:** Automatically maps server ports to Brocade Access Gateway links connected to a fabric switch. Organizations can add blade servers without having to reconfigure the fabric.
- **Path failover:** Automatically reroutes traffic to the remaining links if a link fails between the Brocade Access Gateway and the fabric switch.
- **Brocade Access Gateway ISL trunking:** Provides frame-based trunking across multiple links for higher bandwidth utilization and congestion avoidance.
- **Multi-fabric connectivity:** Increases availability by enabling Brocade Access Gateway links to extend to one or two fabrics. If one fabric path becomes unavailable, multi-path drivers in the blade server reroute application traffic to the second fabric.
- **Proactive monitoring and alerting:** Brocade Access Gateway supports MAPS and Flow Vision to help ensure network availability, optimize bandwidth utilization, and maximize fabric performance.

- **ClearLink Diagnostics support:** Brocade Access Gateway supports ClearLink Diagnostic Ports (D_Ports), accelerating fabric deployments and troubleshooting times.
- **Automatic error recovery:** Brocade Access Gateway supports Buffer Credit Recovery and Forward Error Correction (FEC) to improve resiliency and enhance overall application performance and availability.

Adaptive Networking Services

Server and storage consolidation increases fabric bandwidth requirements. And, as virtual servers concentrate more applications on a single server and dynamically move Virtual Machines (VMs) and their applications between physical servers, unexpected congestion can occur in the fabric. Brocade provides the following features to avoid fabric congestion:

- **Quality of Service (QoS):** Helps ensure that high-priority applications receive priority service if congestion occurs.
- **Traffic isolation:** Isolates higher-bandwidth traffic to dedicated links, avoiding congestion and disruption to other traffic flows in the fabric.
- **Fabric dynamic profiles:** Includes special ASIC registers that provide detailed, dynamic information about data flows at each switch port to dynamically optimize performance.

UltraScale Inter-Chassis Links (ICLs)

Brocade X6 Directors with Gen 6 Fibre Channel provide dedicated, high-bandwidth optical UltraScale ICLs that connect two or more director-class switches without consuming ports on the port blade. This allows up to 4 Tbps of dedicated bandwidth between Brocade X6 Directors, enabling flatter, faster, and simpler fabrics that increase consolidation while reducing network complexity and costs.

Continuity

Data centers have become strategic assets charged with ensuring business continuity. Consequently, fabric-assisted data protection is an important asset in keeping up with data growth and the financial and regulatory penalties incurred when data is lost or inaccessible.

Extension

SAN extension over MAN and WAN distances is an essential technology for disaster recovery infrastructures. Key technologies include:

- **FC and IP:** Creates an extended fabric using IP networks to connect devices between remote sites, supporting 1 GbE, 10 GbE, and 40 GbE. Tunneling over a WAN creates a single extended fabric supporting Fibre Channel, FICON, and IP.
- **Extension Trunking:** Combines multiple WAN connections into a single, logical, high-bandwidth trunk, providing active load balancing and network resilience to protect against WAN link failures.
- **IPsec support:** Ensures secure transport over WAN links by encrypting data-in-flight with a standard 256-bit AES algorithm without a performance penalty.

- **Unparalleled, extremely efficient architecture:** Uniquely permits the high-speed, low-latency processing of frames, making extension of synchronous applications possible.
- **Adaptive Rate Limiting:** Dynamically adjusts bandwidth sharing between minimum and maximum rate limits to optimize bandwidth utilization and maintain WAN performance during disruptions.
- **Advanced compression architecture:** Provides multiple modes to optimize compression ratios for various throughput requirements.
- **WAN-optimized TCP:** Provides an aggressive TCP stack, optimizing TCP window size and flow control, and accelerating TCP transport for high-throughput storage applications
- **Priority TCP Quality of Service (PTQ):** Provides high-, medium-, and low-priority handling of initiator-target flows within the same tunnel for transmission over the WAN, with individual TCP sessions per QoS class.
- **FCIP Fast Write:** Accelerates SCSI write processing, maximizing performance of synchronous and asynchronous replication applications across high-latency WAN connections over any distance.
- **Open Systems Tape Pipelining:** Accelerates read and write tape processing over distance, significantly reducing backup and recovery times over distance anywhere in the world.
- **Brocade Advanced Accelerator for FICON:** Uses advanced networking technologies, data management techniques, and protocol intelligence to accelerate IBM zGM, mainframe tape read and write operations, and z/OS host connection to Teradata warehousing systems over distance.

- **xWDM:** Supports FCP and FICON links over xWDM networks at 1, 2, 4, 8, 10, and 16 Gbps link rates with optimized BB_Credit allocation based on link distance, so full xWDM bandwidth is available.
- **Non-disruptive firmware upgrades:** Provides enterprise-class availability with the industry's only WAN-side, non-disruptive firmware upgrades to achieve always-on business operations and maximize application uptime.

Virtualization

Virtualization increases the utilization of shared resources, including servers, the SAN fabric, and storage devices. Brocade Adaptive Networking services help ensure the highest utilization of shared resources by avoiding congestion and application disruption. Key features include:

- **Virtual Channels:** Brocade Virtual Channels enable traffic separation and classification within a single physical connection, supporting QoS so high-priority traffic continues to flow when congestion occurs.
- **NPIV (switch and Brocade Access Gateway mode):** N_Port ID Virtualization (NPIV) is used with Brocade Access Gateway mode to multiplex blade server connections onto a single high-bandwidth switch port and with VMs to match fabric services to application service levels.
- **Virtual Fabrics:** This ANSI T11 standard feature enables organizations to define logical switches and fabrics that overlay the physical switching layer. In large fabrics, this approach provides better resource utilization, improved fault isolation, and distinct management domains.

Data Protection

Data protection has become a mission-critical requirement for next-generation data centers. Brocade has more than 25 years of data center experience, and has developed an extensive suite of data protection features for access control and security.

Access Control

Access controls are critical tools for data protection, identifying who or what is allowed to connect, communicate, and move data. Brocade products support user and management application access controls, including HTTPS, Secure Shell (SSH), Secure Socket Layer (SSL), Secure Copy (SCP), LDAP/OpenLDAP integration with Microsoft Active Directory, Role-Based Access Control (RBAC), password policies, RADIUS, TACACS+, IP filters, and Passive FTP.

Additional innovative fabric and device access controls include:

- **Switch Connection Control (SCC) policies:** Restrict which switches can connect in a fabric using an Access Control List (ACL). SCC policies can be centrally managed and pushed to the entire fabric.
- **Device Connection Control (DCC) policies:** Restrict which devices (servers, storage, tape) can connect to which switch ports. DCC policies can be centrally managed and pushed to the entire fabric.
- **Password control database:** Contains user accounts, roles, and account passwords, and is distributed to all switches in a fabric to ensure a uniform access control policy.
- **Zoning:** Identifies which devices (servers, storage, tape) are allowed to connect to each other and exchange data.

- **Fabric Configuration Server (FCS):**

All security policies are stored and accessed from the FCS (a designated switch), which simplifies management of all security policies and unifies the application of policies across the fabric.

Security

Security entails authentication and encryption to restrict access and protect data from unauthorized access. Brocade products support a wide range of authentication, encryption, and management tools to protect fabrics and data from unauthorized access:

- **Authentication:** Authentication protocol support includes CHAP, DH-CHAP, FCAP, Internet Key Encryption (IKE), IPsec, RADIUS, TACACS+, and P-EAP/MS-CHAP for RADIUS.
- **Encryption (AES/3-DES):** Brocade provides AES-128 and AES-256 encryption and 168-bit 3-DES encryption for IP links on extension products and management connections. Brocade also supports AES and 3-DES with IPsec. These solutions provide high-performance encryption and compression.
- **In-flight encryption over ISLs:** Brocade X6 with Gen 6 Fibre Channel port blades, Brocade DCX® 8510 with Gen 5 Fibre Channel port blades, and Brocade G630, G620, 6520, and 6510 Switches support in-flight encryption for traffic over ISLs to minimize the risk of unauthorized access to data within the data center and over long-distance links. Data-at-rest and data-in-flight encryption are complementary technologies that serve different purposes, and each may be required in order to achieve regulatory compliance.

Operational Management

Brocade Network Advisor helps organizations manage the entire network management lifecycle, automating time-consuming tasks and freeing up valuable resources. The easy-to-use graphical user interface minimizes administrative effort for tasks such as network upgrades, guiding the user through otherwise complex operational tasks. In addition, bulk deployment and configuration automation provide significant time savings compared to repetitive switch-by-switch administrative tasks, reducing costs and increasing resource efficiency.

Global Support

Global Support has the expertise to help organizations build resilient, efficient SAN infrastructures. Leveraging 20+ years of expertise in storage networking, Global Support delivers world-class technical support, implementation, and migration services to enable organizations to maximize their hardware and software investments, accelerate new technology deployments, and optimize the performance of their overall network.

Additional Brocade Resources

A wide variety of Brocade product data sheets, white papers, and technical briefs that describe key technologies and solutions are available on the Brocade product pages online. In addition, Brocade provides classroom, self-paced, and virtual classroom training materials. Self-paced materials are also available online to provide just-in-time training. To learn more, refer to the following resources:

Brocade products:

www.broadcom.com/products/fibre-channel-networking

Brocade training courses:

www.broadcom.com/support/fibre-channel-networking/education

Maximizing Investments

To help optimize technology investments, Brocade, A Broadcom Inc. Company, and its partners offer complete solutions that include professional services, technical support, and education. For more information, contact a Brocade sales partner or visit

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