

IBM Storage Networking SAN768C-6 Product Guide



Storage

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This IBM® Redbooks® Product Guide describes the IBM Storage Networking SAN768C-6. IBM Storage Networking SAN768C-6 has the industry's highest port density for a storage area network (SAN) director and features 768 line-rate 32 gigabits per second (Gbps) or 16 Gbps Fibre Channel ports.

Designed to support multiprotocol workloads, IBM Storage Networking SAN768C-6 enables SAN consolidation and collapsed-core solutions for large enterprises, which reduces the number of managed switches and leads to easy-to-manage deployments.¹ By reducing the number of front-panel ports that are used on inter-switch links (ISLs), it also offers room for future growth. IBM Storage Networking SAN768C-6 addresses the mounting storage requirements of today's large virtualized data centers.

As a director-class SAN switch, IBM Storage Networking SAN768C-6 uses the same operating system and management interface as other IBM Storage Networking c-type data center switches and directors. It brings intelligent capabilities to a high-performance, protocol-independent switch fabric, and delivers uncompromising availability, security, scalability, simplified management, and the flexibility to integrate new technologies. You can use IBM Storage Networking SAN768C-6 to transparently deploy unified fabrics with Fibre Channel connectivity to achieve low total cost of ownership (TCO).

For mission-critical enterprise storage networks that require secure, robust, cost-effective business-continuance services, the FCIP extension module is designed to deliver outstanding SAN extension performance, reducing latency for disk and tape operations with FCIP acceleration features, including FCIP write acceleration and FCIP tape write and read acceleration.

IBM Storage Networking SAN768C-6 is shown in Figure 1.



Figure 1 IBM Storage Networking SAN768C-6

¹ IBM Storage Networking SAN768C-6 supports the 48-Port 32 Gbps Fibre Channel Switching and the 24/10-port SAN Extension Module.

Did you know?

IBM Storage Networking SAN768C-6 helps you to achieve the following goals:

- ▶ Use up to 768 32-Gbps Fibre per chassis
- ▶ Enable large and scalable deployment of SAN extension solutions with the 24/10-port SAN Extension Module
- ▶ Deliver high availability with fully redundant components, including fabric cards, supervisors, and power supplies
- ▶ Enable exceptional networking capabilities with intelligent fabric services
- ▶ Deploy virtual storage area networks (VSANs) for consolidating physical storage area network (SAN) islands while maintaining logical boundaries
- ▶ Provide Inter-VSAN Routing (IVR) for sharing resources across VSANs

Product highlights

IBM Storage Networking SAN768C-6 offers the following features:

- ▶ Outstanding SAN performance

The combination of the 32 Gbps Fibre Channel switching module and Fabric-1 crossbar switching modules enables up to 1.5 terabits per second (Tbps) of front-panel Fibre Channel throughput between modules in each direction for each of the 16 payload slots.

Based on central arbitration and a crossbar fabric, IBM Storage Networking SAN768C-6 architecture provides 32 Gbps line-rate, nonblocking, predictable performance across all traffic conditions for every port in the chassis.

► High availability

IBM Storage Networking SAN768C-6 provides best-in-class availability. The director meets the same industry-leading availability standards as the other IBM Storage Networking c-type family Directors. All major components, including the fabric card, are redundant. You get grid redundancy on the power supply and 1+1 redundant supervisors, and you can add a fabric card to enable N+1 fabric redundancy at 16-Gbps Fibre Channel speeds.

The suggested number of modules per chassis is six if there are 32-Gbps line linecards with 32-Gbps transceivers. If you do not want to upgrade, or you want to partially upgrade, review Table 1, which shows the number of Fabric Modules needed with ports running at 32 Gbps performance in a 48-port 32-Gbps linecard.

Table 1 Fabric Modules required

| # of ports | Running at (Performance) | # of fabric modules needed | Restrictions |
|------------|--------------------------|----------------------------|--------------------------|
| 24 | 32 Gbps | 3 | Other 24 ports shut down |
| 32 | 32 Gbps | 4 | Other 16 ports shut down |
| 40 | 32 Gbps | 5 | Other 8 ports shut down |
| 48 | 32 Gbps | 6 | No restrictions |

IBM Storage Networking SAN768C-6 combines nondisruptive software upgrades, stateful process restart and failover, and full redundancy of all major components for best-in-class availability.

► Business continuity

Enables large and scalable deployment of SAN extension solutions through the SAN Extension module.

► Industry-leading scalability

Power the largest storage environments with up to 48 Tbps of Fibre Channel bandwidth. A single chassis delivers 768 2/4/8 Gbps, 4/8 Gbps, 4/8/16 Gbps, or 8/16/32 Gbps full line-rate autosensing Fibre Channel ports.

► Intelligent network services

You can use IBM Storage Networking SAN768C-6 to migrate your SAN islands to enterprise-wide storage networks with VSAN technology, access control lists (ACLs) for hardware-based intelligent frame processing, and fabric-wide quality of service (QoS). Consider the following points:

- Integrated hardware-based VSANs and Inter-VSAN Routing (IVR): Integration of VSANs into port-level hardware allows any port in a system or fabric to be partitioned to any VSAN. Line-rate routing can be delivered between any ports in a system or fabric without external routing appliances.

- Intelligent storage services: IBM Storage Networking SAN768C-6 provides interoperability with intelligent service capabilities on other IBM Storage Networking c-type family platforms, and the intelligent services switch provides services, such as acceleration of storage applications for data replication, backup, and data migration to hosts and targets.
 - Smart zoning: Efficiently provision hardware access control entries that are specified by the zone set. Match smart zones to applications, application clusters, hypervisor clusters, or other data center entities. Avoid superfluous entries that allow servers (initiators) to talk to other servers or storage devices (targets) to talk to other storage devices. You gain larger zones with multiple initiators and targets without the use of excessive hardware resources. Zoning tasks can be automated, and the creation of many small zones can be avoided.
 - Enhanced zoning: With basic zoning, two or more administrators can make simultaneous configuration changes. Upon activation, one administrator can overwrite the changes of another administrator. With enhanced zoning, all configuration is performed within a single configuration session. When a session begins, the switch locks down the entire fabric to implement the change, which helps ensure consistency with the fabric.
- ▶ Virtual machine transparency

Deterministic hardware performance and a comprehensive feature set allow virtual machines to have the same SAN attributes as a physical server. On a per-virtual machine basis, the NX-OS Software offers VSANs, QoS policies, access control, performance monitoring, and data protection to promote the scalability and mobility of virtual machines.

Data Center Network Manager (DCNM) provides end-to-end visibility from the virtual machine to the storage device, with resource allocation, performance measurements, and predictions available on a per-virtual machine basis to enable rapid troubleshooting in mission-critical virtualized environments.
 - ▶ Comprehensive security

In addition to support for services, such as VSANs, hardware-enforced zoning, ACLs, per-VSAN role-based access control (RBAC), and TrustSec Fibre Channel link encryption, the IBM Storage Networking c-type family supports a comprehensive security framework that consists of RADIUS and TACACS+, Fibre Channel Security Protocol (FC-SP), Secure File Transfer Protocol (SFTP), Secure Shell (SSH) Protocol, and Simple Network Management Protocol Version 3 (SNMPv3).

TrustSec Fibre Channel link encryption delivers transparent, hardware-based 32 Gbps line-rate encryption of Fibre Channel data on 32 Gbps Fibre Channel switching modules.
 - ▶ Unified SAN management

The IBM Storage Networking c-type family includes built-in storage network management with all features that are available through a command-line interface (CLI) or DCNM, which is a centralized network management tool that simplifies management of unified fabrics. The network manager supports integration with third-party storage management applications to allow transparent interaction with management tools. The network manager supports federation of up to 10 DCNM servers to manage up to 150,000 devices by using a single management pane.

► **Sophisticated diagnostics**

Intelligent diagnostics, protocol decoding, network analysis tools, and the Call Home capability give you reliability, faster problem resolution, and reduced service costs. Starting with NX-OS Software Release 6.2, the Generic Online Diagnostics (GOLD) framework replaces the Online Health Management System (OHMS) diagnostic framework on the IBM Storage Networking c-type family chassis. The GOLD framework is a suite of diagnostic tools that verify that hardware and internal data paths are operating properly.

It offers boot-time diagnostics, continuous monitoring, standby fabric loopback tests, and on-demand and scheduled tests. It also enables the rapid fault isolation and systems monitoring that are critical in today's continuously evolving operating environments.

Main benefits

IBM Storage Networking SAN768C-6 provides the benefits that are described in this section.

Lower TCO with SAN consolidation

With exponential data growth and the pressures to do more with less, organizations must deploy large-scale SANs in the most efficient, cost-effective way possible. IBM Storage Networking SAN768C-6 can meet scalability and TCO requirements. It offers industry-leading port densities of up to 768 32 Gbps Fibre Channel ports per chassis, so there is enough room to grow.

By using IBM Storage Networking SAN768C-6, organizations can consolidate and collapse from edge-core-edge to edge-core or collapsed core architectures. Performance can reach up to 1.5 Tbps front-panel Fibre Channel capacity per slot, extending up to 48 Tbps front-panel Fibre Channel, line-rate, nonblocking system-level switching capacity.

By consolidating data into fewer, larger, and more manageable SANs, you can reduce your total hardware footprint and related capital and operating expenses.

Enterprise-class availability

IBM Storage Networking SAN768C-6 is designed for high availability. Beyond meeting the basic requirements of nondisruptive software upgrades and redundancy of critical hardware components, the IBM Storage Networking SAN768C-6 software architecture offers outstanding availability.

Its supervisor modules automatically restart failed processes, which makes IBM Storage Networking SAN768C-6 exceptionally robust. In the rare event that a supervisor module is reset, complete synchronization between the active and standby supervisor modules helps ensure stateful failover with no disruption of traffic.

IBM Storage Networking SAN768C-6 supports the Supervisor – 1E for heavier workloads. It does not support the Supervisor – 1, which is supported on IBM Storage Networking SAN192C-6 and IBM Storage Networking SAN384C-6 platforms. However, IBM Storage Networking SAN192C-6 and IBM Storage Networking SAN384C-6 do not support the Supervisor – 1E.

IBM Storage Networking SAN768C-6 provides redundancy on all major hardware components, as listed in Table 2.

Table 2 Redundancy details for IBM Storage Networking SAN768C-6

| Component | Redundancy |
|----------------|-----------------|
| Supervisors | 1+1 redundancy |
| Power supplies | Grid redundancy |
| Fabrics | N+1 redundancy |

High availability is implemented at the fabric level by using robust and high-performance ISLs. The port-channel capability allows you to aggregate up to 16 physical links into one logical bundle. The bundle can consist of any speed-matched ports in the chassis, which helps ensure that the bundle can remain active if a port, application-specific integrated circuit (ASIC), or module fails.

ISLs in a port channel can have different lengths. This capability is valuable in campus and metropolitan area network (MAN) environments because logical links can now be spread over multiple physical paths, which helps ensure uninterrupted connectivity even if one of the physical paths is disrupted. IBM Storage Networking SAN768C-6 provides outstanding high availability, which helps ensure that solutions exceed the 99.999% uptime requirements of today's most demanding environments.

Business continuity

The 24/10-Port SAN Extension Module is supported on IBM Storage Networking c-type family Directors. With 24 line-rate 2-, 4-, 8-, 16-, and 32-Gbps Fibre Channel ports and eight 1 and 10 Gigabit Ethernet Fibre Channel over IP (FCIP) ports, this module enables large and scalable deployment of SAN extension solutions. The SAN extension module has two independent service engines that can each be individually and incrementally enabled to scale as business requirements expand.

Business transformation with enterprise cloud deployment

Enterprise clouds provide organizations with elastic compute and network capabilities, which enable IT to scale up or scale down resources on an as-needed basis in a quick and cost-efficient manner. IBM Storage Networking SAN768C-6 meets the needs of enterprise clouds by providing the following features:

- ▶ Outstanding scalability and pay-as-you-grow flexibility
- ▶ Robust security for multi-tenant cloud applications
- ▶ Consistent high performance to meet stringent service-level agreements (SLAs)
- ▶ Resilient connectivity for no-downtime cloud infrastructures
- ▶ Advanced traffic management capabilities, such as QoS, to quickly and cost-efficiently allocate elastic network capabilities to cloud applications

Data Center Network Manager for SAN (DCNM-SAN) provides resource monitoring and capacity planning on a per-virtual machine basis. This feature enables efficient, consolidated enterprise cloud deployments, federation of up to 10 DCNM servers for ease of management of large-scale clouds, and access to resource usage information through Storage Management Initiative Specification (SMI-S)-based application programming interfaces (APIs) to deliver IT as a service.

Advanced traffic management

IBM Storage Networking SAN768C-6 can be used to deploy and optimize large-scale fabrics more easily with the following features:

- ▶ Virtual output queue (VOQ): Helps ensure line-rate performance on each port, independent of traffic pattern, by eliminating head-of-line blocking.
- ▶ Up to 4095 buffer-to-buffer credits: Using extended credits, allows up to 4095 buffer credits from a pool of more than 6000 buffer credits for a module. These credits can be allocated to ports as needed, which greatly extends the distance of Fibre Channel SANs. Alternatively, 4095 buffer credits can be assigned to an individual port for optimal bandwidth utilization across distance.
- ▶ Port Channels: Aggregate up to 16 physical ISLs into a single logical bundle, which provides optimized bandwidth utilization across all links. The bundle can consist of any speed-matched ports from any module in the chassis. This feature helps ensure that the bundle remains active even with a module failure. The IBM Storage Networking c-type family switch architecture helps ensure that frames can never be reordered within a switch.
- ▶ QoS: Manage bandwidth and control latency to prioritize critical traffic.

Ease of management

To meet the needs of all users, IBM Storage Networking SAN768C-6 supports management via NX-API, the CLI, DCNM, and third-party storage management tools.

NX-API is a Representational State Transfer (REST) API-based framework for NX-OS. It provides output of CLIs in an easy-to-read XML or JavaScript Object Notation (JSON) format for simple scriptability. NX-API is considerably faster than Simple Network Management Protocol (SNMP) queries in terms of data collection time from a switch. It also can be used by DCNM and third-party management tools.

IBM Storage Networking SAN768C-6 also features a consistent, logical CLI. The CLI is easy to learn and delivers broad management capabilities. It is an efficient and direct interface that is designed to streamline tasks in enterprise environments.

DCNM is an easy-to-use application that simplifies management across multiple switches and converged fabrics. Focused on supporting efficient operations and management of virtual machine-aware fabrics, DCNM provides a robust framework and rich feature set that meet the routing, switching, and storage administration needs of present and future virtualized data centers. It streamlines provisioning of the unified fabric and proactively monitors the SAN components. DCNM can also be used with third-party management applications.

The DCNM features provide the following benefits:

- ▶ End-to-end performance management of SAN networks
- ▶ Self-service provisioning of intelligent and scalable fabrics
- ▶ Centralized fabric management to facilitate resource movements, additions, and changes
- ▶ Proactive monitoring of SAN and detection of performance degradation
- ▶ Easier diagnosis and troubleshooting of data center outages
- ▶ Simplified operational management of virtualized data centers
- ▶ Intuitive, large-scale fabric visualization with domain views
- ▶ Fibre Channel slow-drain analysis and host-path redundancy
- ▶ Scale out architecture with the use of server-based federation
- ▶ Rule-based event notification and filtering
- ▶ RBAC to provide separation between network and storage teams

IBM Storage Networking SAN768C-6 also supports power-on autoprovisioning (POAP) to automate software image upgrades and configuration file installation on newly deployed switches.

Comprehensive solution for robust security

The extensive security framework of IBM Storage Networking SAN768C-6 protects sensitive data that is crossing enterprise networks. It features intelligent, port-level packet inspection, including the use of access control lists (ACLs) for hardware enforcement of zones, VSANs, and advanced port security features.

VSANs are used to achieve greater security and stability by providing complete isolation of devices that are connected to the same physical SAN. IVR enables controlled sharing of resources between VSANs. In addition, FC-SP provides switch-to-switch and host-to-switch Diffie-Hellman Challenge Handshake Authentication Protocol (DH-CHAP) that supports RADIUS and TACACS+.

This feature helps ensure that only authorized devices access protected storage networks. To further protect traffic within and between data centers, TrustSec Fibre Channel link encryption allows you to transparently encrypt ISLs at up to line-rate speeds.

Advanced diagnostics and troubleshooting tools

Managing large-scale storage networks requires proactive diagnostics, tools to verify connectivity and route latency, and mechanisms for capturing and analyzing traffic. Comprehensive port-based and flow-based statistics enable sophisticated performance analysis and SLA accounting.

In addition, integrated Call Home capability is provided for added reliability, faster problem resolution, and reduced service costs. With IBM Storage Networking SAN768C-6, IBM delivers a comprehensive toolset for troubleshooting, analysis, and debugging of storage networks.

POST and online diagnostics proactively monitor system health. You can identify the exact path and timing of flows with capabilities, such as Fibre Channel traceroute. You can capture network traffic by using Switched Port Analyzer (SPAN) and Remote SPAN (RSPAN). Then, you can analyze traffic with Fabric Analyzer, an embedded Fibre Channel analyzer. You can perform sophisticated performance analysis and SLA accounting by collecting port-based and flow-based statistics.

24/10-Port SAN Extension Module for IBM Storage Networking c-type family Directors

The 24/10-Port SAN Extension Module provides a high-performance, flexible, unified platform for deploying enterprise-class disaster-recovery and business-continuance SAN extension solutions. See Figure 2 on page 9.

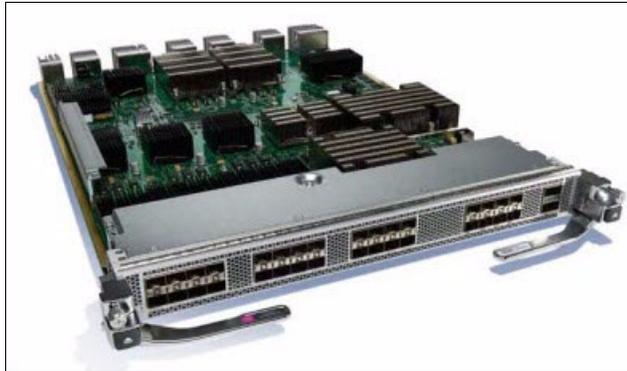


Figure 2 24/10-Port SAN Extension Module

The 24/10-Port SAN Extension Module is supported on IBM Storage Networking c-type family Directors. With 24 line-rate 2-, 4-, 8-, 10-, and 16-Gbps Fibre Channel ports, and eight 1 and 10 Gigabit Ethernet Fibre Channel over IP (FCIP) ports, this module enables large and scalable deployment of SAN extension solutions. The SAN extension module has two independent service engines that can each be individually and incrementally enabled to scale as business requirements expand.

The SAN extension module supports the full range of services available on other IBM Storage Networking c-type family Fibre Channel switching modules, including virtual SAN (VSAN), security, and traffic management services. The FCIP module uses IBM expertise and knowledge of IP networks to deliver outstanding SAN extension performance, reducing latency for disk and tape operations with FCIP acceleration features, including FCIP write acceleration and FCIP tape write and read acceleration.

Hardware-based encryption helps secure sensitive traffic with IP Security (IPsec), and hardware-based compression dramatically enhances performance for both high- and low-speed links, enabling immediate cost savings in expensive WAN infrastructure. Multiple FCIP interfaces within a single engine or across service engines can be grouped into a port channel of up to 16 links for high availability and increased aggregate throughput.

Main features and benefits

The 24/10-Port SAN Extension Module is designed for mission-critical enterprise storage networks that require secure, robust, cost-effective business-continuance services. The SAN extension module offers the following main features:

- ▶ FCIP for remote SAN extension:
 - Simplifies data-protection and business-continuance strategies by enabling backup, remote replication, and other disaster-recovery services over WAN distances using open standards FCIP tunneling.
 - Optimizes utilization of WAN resources for backup and replication by enabling hardware-based compression, hardware-based encryption, FCIP write acceleration, and tape read and write acceleration for both FCIP and IBM FICON® over IP. The SAN extension module will support 4 tunnels per interface, and can scale up to 32 tunnels (4 tunnels x 8 1/10 GbE ports).
 - Preserves IBM Storage Networking c-type family enhanced capabilities, including VSANs, advanced traffic management, and security, across remote connections.

- ▶ Integrated IP storage services in a high-density form factor: The module supports eight 1 and 10 Gigabit Ethernet ports. Individual ports can be configured with hot-swappable shortwave and longwave Small Form-Factor Pluggable (SFP) connections.
- ▶ Integrated hardware-based VSANs and Inter-VSAN Routing (IVR): The module enables deployment of large-scale multisite and heterogeneous SAN topologies. Integration into port-level hardware allows any port in a system or fabric to be partitioned into any VSAN. Integrated hardware-based IVR provides line-rate routing between any ports in a system or fabric without the need for external routing appliances.
- ▶ Intelligent network services: The module uses VSAN technology for hardware-enforced, isolated environments in a single physical fabric, access control lists (ACLs) for hardware-based intelligent frame processing, and advanced traffic management features, such as fabric-wide quality of service (QoS) to facilitate migration from SAN islands to enterprise-wide storage networks.
- ▶ Sophisticated diagnostics: The module provides intelligent diagnostics, protocol decoding, and network analysis tools, as well as integrated Call Home capability for greater reliability, faster problem resolution, and reduced service costs.
- ▶ Comprehensive network security framework: The module supports RADIUS and TACACS+, Fibre Channel Security Protocol (FC-SP), Secure File Transfer Protocol (SFTP), Secure Shell (SSH) Protocol, Simple Network Management Protocol Version 3 (SNMPv3) implementing the Advanced Encryption Standard (AES), VSANs, hardware-enforced zoning, ACLs, and per-VSAN role-based access control (RBAC).
RBAC provides separate control over management functions and access on a per-VSAN basis, enabling separation of duties among administrators on the same physical switch. Gigabit Ethernet (GbE) ports support IPsec authentication, data integrity, and hardware-assisted data encryption.
- ▶ IP Version 6 (IPv6) support: The module supports IPv6 as mandated by the US Department of Defense (DoD), Japan, and China. IPv6 support is provided for FCIP, and for management traffic routed in band and out of band.

Integrated FCIP for remote SAN and mainframe channel extension

Data-distribution, data-protection, and business-continuance services are significant components of today's information-centered businesses. The capability to efficiently replicate critical data on a global scale helps ensure a higher level of data protection for valuable corporate information, and it also increases utilization of backup resources and lowers total cost of storage ownership. The 24/10-Port SAN Extension Module uses the open-standards FCIP protocol to extend the distance of current Fibre Channel and FICON solutions, enabling interconnection of SAN islands over extended distances.

Advanced SAN extension features

The 24/10-Port SAN Extension Module supports hardware-based FCIP compression to increase the effective WAN bandwidth of SAN extension solutions. The module can deliver compression ratios in the range of 4:1 - 5:1 over a wide variety of data sources.

The SAN extension module supports AES 256 IPsec encryption for secure transmission of sensitive data over extended distances. Hardware enablement of IPsec helps ensure line-rate throughput. Together, hardware-based compression and hardware-based encryption provide a high-performance, highly secure SAN extension capability.

Additionally, the SAN extension module supports FCIP write acceleration, a feature that can significantly improve application performance when storage traffic is extended across long distances. When FCIP write acceleration is enabled, WAN throughput is optimized by reducing the latency of command acknowledgments.

VSANs

Well suited for efficient, secure SAN consolidation, ANSI T11-standard VSANs enable more efficient storage network utilization by creating hardware-based isolated environments with a single physical SAN fabric or switch. Each VSAN can be zoned as a typical SAN and maintained with its own fabric services for greater scalability and resilience. VSANs allow the cost of SAN infrastructure to be shared among more users, while helping ensure segregation of traffic and retaining independent control of configuration on a VSAN-by-VSAN basis.

Integrated SAN routing

In another step toward deployment of efficient, cost-effective, consolidated storage networks, the 24/10-Port SAN Extension Module supports IVR, the industry's first and most efficient routing function for Fibre Channel. IVR allows selective transfer of data between specific initiators and targets on different VSANs while maintaining isolation of control traffic within each VSAN.

With IVR, data can transit VSAN boundaries while maintaining control-plane isolation, thereby maintaining fabric stability and availability. IVR eliminates the need for external routing appliances, greatly increasing routing scalability while delivering line-rate routing performance, simplifying management, and eliminating the challenges associated with maintaining separate systems. IVR reduces the total cost of SAN ownership.

Advanced Traffic Management

The following advanced traffic management capabilities integrated into the 24/10-Port SAN Extension Module simplify deployment and optimization of large-scale fabrics:

- ▶ **Virtual output queuing:** Helps ensure line-rate performance on each port, independent of traffic pattern, by eliminating head-of-line blocking.
- ▶ **Port channels:** Allow users to aggregate up to 16 FCIP ISLs into a single logical bundle, providing optimized bandwidth utilization across all links. The bundle can consist of any speed-matched ports from any module in the chassis, helping ensure that the bundle can remain active even in the event of a module failure.
- ▶ **Fabric Shortest Path First (FSPF)-based multipathing:** Provides the intelligence to load-balance traffic across up to 16 equal-cost paths and, in the event of a switch failure, dynamically reroute traffic.
- ▶ **QoS:** Can be used to manage bandwidth and control latency, to prioritize critical traffic.
- ▶ **Shaper:** Rate limits the WAN bandwidth according to the maximum bandwidth configured for the FCIP tunnel.

Advanced diagnostics and troubleshooting tools

Management of large-scale storage networks requires proactive diagnostics, tools to verify connectivity and route latency, and mechanisms for capturing and analyzing traffic. The IBM Storage Networking c-type family integrates the industry's most advanced analysis and diagnostic tools. Power-on self-test (POST) and online diagnostics provide proactive health monitoring.

The 24/10-Port SAN Extension Module implements diagnostic capabilities, such as Fibre Channel Traceroute to detail the exact path and timing of flows, and Switched Port Analyzer (SPAN) to intelligently capture network traffic. The module also supports the SAN Extension Tuner (SET) tool, which helps you optimize FCIP performance by generating either direct-access (for magnetic disks) or sequential-access (for magnetic tape) Small Computer System Interface (SCSI) I/O commands, and directing this traffic to a specific virtual target.

You can specify the size of the test I/O transfers and the number of concurrent or serial I/O operations to generate while testing. The SET tool reports the resulting I/O operations per second (IOPS) and I/O latency, which helps you determine the number of concurrent I/O operations needed to get the best FCIP throughput.

After traffic has been captured, it can be analyzed with the Fabric Analyzer, an embedded Fibre Channel analyzer. Comprehensive port-based and flow-based statistics facilitate sophisticated performance analysis and service-level agreement (SLA) accounting. With the IBM Storage Networking c-type family, IBM delivers a comprehensive tool set for troubleshooting and analyzing storage networks.

Comprehensive solution for robust network security

Addressing the need for fail-proof security in storage networks, the 24/10-Port SAN Extension Module offers an extensive security framework to protect highly sensitive data moving in today's enterprise networks.

The module employs intelligent frame inspection at the port level, including the application of ACLs for hardware enforcement of zones, VSANs, and advanced port security features:

- ▶ Extended zoning capabilities restrict broadcasts to only the selected zones (broadcast zones).
- ▶ VSANs are used to achieve greater security and stability by providing complete isolation among devices that are connected to the same physical SAN.
- ▶ FC-SP provides switch-to-switch and host-to-switch Diffie-Hellman Challenge Handshake Authentication Protocol (DH-CHAP) authentication supporting RADIUS and TACACS+, to help ensure that only authorized devices can access protected storage networks.

48-Port 32-Gbps Fibre Channel Switching Module

The 48-Port 32-Gbps Fibre Channel Switching Module (Figure 3 on page 13) delivers predictable performance, scalability, and innovative features to support private and virtualized data centers. With industry-leading 768 line-rate 32-Gbps Fibre Channel ports per director, the 32-Gbps 48-port Fibre Channel switching module meets the high-performance needs for flash-memory and Non-Volatile Memory Express (NVMe) over Fibre Channel workloads.

It offers innovative services including virtual machine awareness, on-board Fibre Channel analytics engine, E-port and F-port diagnostics, integrated VSANs, Inter-VSAN Routing (IVR), and port channels. It delivers full-duplex aggregate performance of 1536 Gbps, making it well suited for high-speed 32-Gbps storage subsystems, 32-Gbps Inter-Switch Links (ISLs), high-performance virtualized servers, and all-flash and NVMe arrays.



Figure 3 48-Port 32-Gbps Fibre Channel Switching Module

The 48-Port 32-Gbps Fibre Channel Switching Module enables administrators to scale and consolidate SAN deployments with fewer hardware components. Your SAN administrators can consolidate workloads from hundreds of high-performance virtual machines and scale them with incremental updates as your SAN grows while protecting your existing investment.

This switching module ships with a built-in analytics engine. The engine can analyze real-time Fibre Channel exchanges and report on various metrics in detail, enabling comprehensive and timely monitoring of any potential performance problems among SAN edge devices. The on-board network processing unit (NPU) in the module allows I/O-level metrics to be computed at every switch. The NPU can monitor all flows on all ports at line rate.

The NPU examines every exchange passing through the 32-Gbps application-specific integrated circuit (ASIC) to capture flow metrics such as exchange completion time, maximum number of outstanding exchanges, data access latency, read and write I/O operations per second (IOPS), throughput, logical unit number (LUN) access pattern (sequential or random), and I/O block sizes.

The switching module is hot swappable and compatible with 4-, 8-, 16-, and 32-Gbps Fibre Channel interfaces. This module also supports hot-swappable Enhanced Small Form-Factor Pluggable (SFP+) transceivers. Individual ports can be configured with 32-, 16-, and 8-Gbps SFP+ transceivers. Each port supports 500 buffer credits for exceptional extensibility without the need for additional licenses. With the Enterprise Package license, up to 8191 buffer credits can be allocated to an individual port, enabling full link bandwidth over long distances with no degradation in link utilization.

The 32-Gbps Fibre Channel switching module also provides existing features such as predictable performance, high availability, advanced traffic management capabilities, integrated VSAN and IVR, resilient high-performance ISLs, hardware-assisted slow-drain support, comprehensive security frameworks, fault detection and isolation of errored packets, and sophisticated diagnostics.

Main features

The 48-Port 32-Gbps Fibre Channel Switching Module offers the following main features:

- ▶ **Outstanding SAN performance:** The combination of the 32-Gbps Fibre Channel switching module and Fabric-1 crossbar switching modules enables up to 1.5 terabits per second (Tbps) of Fibre Channel throughput between the modules in each direction for each payload slot in the IBM Storage Networking c-type family Multilayer Directors. The IBM Storage Networking c-type family architecture, which is based on central arbitration and a crossbar fabric, provides 32-Gbps line-rate, nonblocking, predictable performance across all traffic conditions for every port in the chassis.
- ▶ **High availability:** The IBM Storage Networking c-type family directors provide outstanding availability and reliability. They are the industry's first director-class switches considered to support mission-critical workloads because they enable redundancy on all major components, including the fabric card. They also provide grid redundancy on the power supply and 1+1 redundant supervisors. Users can add a fabric card to enable N+1 fabric redundancy at 16-Gbps Fibre Channel speeds. See Table 1 on page 3.
- ▶ **Industry-leading scalability:** The IBM Storage Networking c-type family directors combine industry-leading scalability with performance to meet the needs of even the largest data center storage environments. IBM Storage Networking SAN768C-6 supports up to 48 Tbps of Fibre Channel system bandwidth and 768 2-, 4-, 8-, 16-, and 32-Gbps full line-rate autosensing Fibre Channel ports in a single chassis. IBM Storage Networking SAN384C-6 supports up to 24 Tbps of Fibre Channel system bandwidth and up to 384 2-, 4-, 8-, 16-, and 32-Gbps full line-rate autosensing Fibre Channel ports in a single chassis.

The smaller IBM Storage Networking SAN192C-6 supports up to 12 Tbps of Fibre Channel system bandwidth and 192 2-, 4-, 8-, 16-, and 32-Gbps full line-rate autosensing Fibre Channel ports in a single chassis. The IBM Storage Networking c-type family directors can support both the 48-Port 16-Gbps Fibre Channel Switching Module and the 48-Port 32-Gbps Fibre Channel Switching Module in the same chassis, providing compatibility with the customer's existing system.

- ▶ **Intelligent network services:** VSAN technology, access control lists (ACLs) for hardware-based intelligent frame processing, and fabricwide quality of service (QoS) enable migration from SAN islands to enterprise wide storage networks.
- ▶ **Fibre Channel Redirect (FC-Redirect):** FC-Redirect infrastructure provides the capability to redirect a flow to a specific service engine in the fabric to provide intelligent services such as Data Mobility Manager and I/O Accelerator.
- ▶ **Integrated hardware-based VSANs and IVR:** VSANs are integrated into port-level hardware so that any port in a system or fabric can be assigned to any VSAN. The IVR provides line-rate routing between any ports in a system or fabric without the need for external routing appliances.
- ▶ **Intelligent storage services:** The IBM Storage Networking c-type family directors support intelligent service capabilities on other IBM switches to provide services such as acceleration of storage applications for data replication and backup.
- ▶ **Smart Zoning:** When the Smart Zoning feature is enabled, IBM Storage Networking c-type family fabrics provision the hardware ACL entries, specified by the zone set, more efficiently. This feature helps prevent superfluous entries that may allow servers (initiators) to talk to other servers or allow storage devices (targets) to talk to other storage devices.

This feature makes feasible larger zones with multiple initiators and multiple targets without excessive consumption of hardware resources. Smart Zones can correspond to applications, application clusters, hypervisor clusters, and other data center entities, saving the time that administrators previously spent creating many small zones and enabling automation of zoning tasks.

- ▶ **Virtual machine transparency:** The IBM Storage Networking c-type family provides deterministic hardware performance and a comprehensive feature set that allows virtual machines to have the same SAN attributes as a physical server. On a per-virtual machine basis, NX-OS Software offers VSANs, QoS policies, access control, performance monitoring, and data protection to promote the scalability and mobility of virtual machines.

Data Center Network Manager (DCNM) enables rapid troubleshooting in mission-critical virtualized environments by providing end-to-end visibility from the virtual machine to storage with resource allocation, performance measurements, and predictions available on a per-virtual machine basis.

- ▶ **Comprehensive security:** The IBM Storage Networking c-type family devices supports services including VSANs, hardware-enforced zoning, ACLs, per-VSAN role-based access control (RBAC), and TrustSec Fibre Channel link encryption. The comprehensive security framework consists of RADIUS and TACACS+, Fibre Channel Security Protocol (FC-SP), Secure File Transfer Protocol (SFTP), Secure Shell (SSH) Protocol, and Simple Network Management Protocol Version 3 (SNMPv3).

The TrustSec Fibre Channel link encryption delivers transparent, hardware-based 32-Gbps line-rate Advanced Encryption Standard (AES) 128-bit encryption of Fibre Channel data on 32-Gbps Fibre Channel switching modules.

- ▶ **Resilient high-performance ISLs:** The IBM Storage Networking c-type family 32-Gbps Fibre Channel switching modules support high-performance ISLs consisting of 32-Gbps secure Fibre Channel. Fibre Channel switching modules also support port-channel technology for additional scalability and resilience. Administrators can group up to 16 links spanning any port on any module in a chassis into a logical link.

Administrators can also allocate up to 8191 buffer-to-buffer credits to a single Fibre Channel port, providing industry-leading extension of storage networks to up to 4000 kilometers at 4 Gbps, 2000 kilometers at 8 Gbps, 1000 kilometers at 16 Gbps, and 500 kilometers at 32 Gbps, while maintaining full link utilization. The IBM Storage Networking c-type family switch architecture helps ensure that frames are never reordered within a switch, leading to optimal application performance because end devices never have to use resources to reorder the frames.

- ▶ **Sophisticated diagnostics:** The 48-Port 32-Gbps Fibre Channel Switching Module provides intelligent diagnostics, protocol decoding, E-port diagnostics, and network analysis tools along with an integrated Call Home capability for greater reliability, faster problem resolution, and reduced service costs.
- ▶ **Compatibility:** The 48-Port 32-Gbps Fibre Channel Switching Module can co-exist with previous-generation supported modules on the IBM Storage Networking c-type family director.
- ▶ **Investment protection:** The 48-Port 32-Gbps Fibre Channel Switching Module can easily be inserted into existing IBM Storage Networking c-type family directors without any effect on operations.

Main benefits

The 48-Port 32-Gbps Fibre Channel Switching Module offers the following main benefits:

- ▶ Lower total cost of ownership (TCO) with SAN consolidation: With the exponential growth of data in today's business environment, organizations need to deploy large-scale SANs in the most efficient and cost-effective ways. To meet scalability requirements while managing TCO, the IBM Storage Networking c-type family directors offer the following features:
 - Industry-leading port density of line-rate 32-Gbps Fibre Channel ports per chassis
 - 1.5-Tbps Fibre Channel performance per slot
 - Up to 48-Tbps front-panel Fibre Channel line-rate nonblocking system-level switching
 - Exceptional capabilities with intelligent fabric services
 - VSANs for consolidating individual physical SAN islands while maintaining logical boundaries
 - IVR for sharing resources across VSANs
 - Built-in network processing unit for inline analytics

These features enable the consolidation of an organization's data assets into fewer, larger, and more manageable SANs, thus reducing the hardware footprint and associated capital and operating expenses:

- ▶ Enterprise-class availability: The IBM Storage Networking c-type family was specifically designed from the beginning for high-availability and mission-critical environments. Beyond meeting the basic requirements of nondisruptive software upgrades and redundancy of all critical hardware components, the IBM Storage Networking c-type family software architecture offers outstanding greater than five-nines availability.
- ▶ Virtual machine-aware SAN deployment: The growing adoption of server virtualization in data centers increases the number of hosts attached to the SAN, places higher workloads on the SAN, and requires more storage, thereby increasing the need for SAN services. VMpath technology, part of Prime DCM, provides end-to-end visibility from the virtual machines to the storage devices. Resource allocation, performance measurements, and predictions are available on a per-virtual machine basis to enable rapid troubleshooting in mission-critical virtualized environments.
- ▶ Advanced traffic management: The following advanced traffic management capabilities, integrated into every 48-Port 32-Gbps Fibre Channel Switching Module, simplify deployment and optimization of large-scale fabrics:
 - The virtual output queue (VOQ) helps ensure line-rate performance on each port, independent of traffic pattern, by eliminating head-of-line blocking.
 - Up to 8191 buffer-to-buffer credits can be assigned to any individual port for optimal bandwidth utilization across distances.
 - Port channels allow up to 16 physical ISLs to be aggregated into a single logical bundle, providing optimized bandwidth utilization across all links. The bundle can be a mix of any port from any module in the chassis. This approach helps ensure that the bundle can remain active even if a module fails.
 - Fabric Shortest Path First (FSPF)-based multipathing provides the intelligence to load-balance across up to 16 equal-cost paths and dynamically reroute traffic if a switch fails.
 - QoS helps manage bandwidth and control latency to prioritize critical traffic and is available on every port.

- The lossless network-wide in-order delivery guarantee helps ensure that frames are never reordered within a switch. This guarantee extends across the entire multiswitch fabric, assuming that the fabric is stable and no topology changes are made.
- Advanced diagnostics and troubleshooting tools: The IBM Storage Networking c-type family integrates proactive diagnostics, tools to verify connectivity and route latency and to capture and analyze traffic, thereby simplifying the management of large-scale storage networks. The power-on self-test (POST) and online diagnostics provide proactive health monitoring. Starting with NX-OS Software Release 6.2, the powerful Generic Online Diagnostics (GOLD) framework replaces the Online Health Management System (OHMS) diagnostic framework on the IBM Storage Networking c-type family Multilayer Director chassis.

GOLD is a suite of diagnostic facilities that verify whether the hardware and internal data paths are operating as designed. Boot-time diagnostics, continuous monitoring, standby fabric loopback tests, and on-demand and scheduled tests are part of the GOLD feature set. This industry-leading diagnostics subsystem enables rapid fault isolation and continuous system monitoring, which are critical features in today's continuously operating environments.

- Integrated hardware functions support diagnostic capabilities such as Fibre Channel traceroute to identify the exact path and timing of flows, and Switched Port Analyzer (SPAN) and Remote SPAN (RSPAN) to intelligently capture network traffic. The captured Fibre Channel traffic can be analyzed with the embedded Fabric Analyzer. Comprehensive port-based and flow-based statistics enable sophisticated performance analysis and service-level agreement (SLA) accounting.
- Comprehensive solution for robust security: Addressing the need for stringent security in storage networks, the 32-Gbps Fibre Channel line card offers an extensive security framework to protect the highly sensitive data crossing today's enterprise networks. The IBM Storage Networking c-type family employs intelligent packet inspection at the port level, including the application of ACLs for hardware enforcement of zones, VSANs, and advanced port security features. VSANs are used to achieve greater security and stability by providing complete isolation of devices that are connected to the same physical SAN. IVR enables controlled sharing of resources between VSANs.
- In addition, FC-SP1 provides switch-to-switch and host-to-switch Diffie-Hellman Challenge Handshake Authentication Protocol (DH CHAP) authentication supporting RADIUS or TACACS+ to help ensure that only authorized devices access protected storage networks.

TrustSec1 Fibre Channel link encryption, available on the 32-Gbps modules, allows you to transparently encrypt ISLs at up to line-rate speeds, providing an additional layer of protection for traffic within and between data centers. The IBM Storage Networking c-type family supports a fabric binding feature that helps ensure that ISLs are enabled only between specified switches in the fabric binding configuration.

- Integrated mainframe support: The IBM Storage Networking c-type family is mainframe ready, with full support for Fibre Connection (FICON) for IBM z® Systems® and Linux environments. The IBM Storage Networking c-type family supports transport of the FICON protocol in both cascaded and noncascaded fabrics. It also supports a mix of FICON and open-systems Fibre Channel Protocol (FCP) traffic on the same switch.

Product specifications

The specifications for IBM Storage Networking SAN768C-6 are listed in Table 3.

Table 3 Specifications

| Feature | Description |
|------------------------|--|
| Product compatibility | IBM Storage Networking c-type family |
| Software compatibility | NX-OS Software Release 8.1(1b) or later |
| Operating systems | For most current and complete information, see the IBM System Storage® Interoperation Center (SSIC): https://www.ibm.com/systems/support/storage/ssic |
| Optional features | <ul style="list-style-type: none"> ▶ 24/10-port SAN Extension Module (AJL5) ▶ 48-Port 32-Gbps Fibre Channel Switching Module (AJL5) ▶ 48-Port 32-Gbps Fibre Channel Switching Module Bundle (AJL2) ▶ Enterprise Package (AJJ9) ▶ DCNM SAN Advanced Edition (AJJA) ▶ SAN Insights (AJKV) ▶ Small form-factor pluggables (SFPs) ▶ 3000W AC power supply (AJKF) ▶ Fans |
| Indicators | <ul style="list-style-type: none"> ▶ Power supply LED ▶ FAN LED ▶ Supervisor LED ▶ Fabric LED ▶ Line-card module LED |

| Feature | Description |
|-----------|--|
| Protocols | <ul style="list-style-type: none"> ▶ Fibre Channel standards ▶ FC-PH, Revision 4.3 (ANSI INCITS 230-1994) ▶ FC-PH, Amendment 1 (ANSI INCITS 230-1994/AM1-1996) ▶ FC-PH, Amendment 2 (ANSI INCITS 230-1994/AM2-1999) ▶ FC-PH-2, Revision 7.4 (ANSI INCITS 297-1997) ▶ FC-PH-3, Revision 9.4 (ANSI INCITS 303-1998) ▶ FC-PI, Revision 13 (ANSI INCITS 352-2002) ▶ FC-PI-2, Revision 10 (ANSI INCITS 404-2006) ▶ FC-PI-3, Revision 4 (ANSI INCITS 460-2011) ▶ FC-PI-4, Revision 8 (ANSI INCITS 450-2008) ▶ FC-PI-5, Revision 6 (ANSI INCITS 479-2011) ▶ FC-FS, Revision 1.9 (ANSI INCITS 373-2003) ▶ FC-FS-2, Revision 1.01 (ANSI INCITS 424-2007) ▶ FC-FS-2, Amendment 1 (ANSI INCITS 424-2007/AM1-2007) ▶ FC-FS-3, Revision 1.11 (ANSI INCITS 470-2011) ▶ FC-LS, Revision 1.62 (ANSI INCITS 433-2007) ▶ FC-LS-2, Revision 2.21 (ANSI INCITS 477-2011) ▶ FC-SW-2, Revision 5.3 (ANSI INCITS 355-2001) ▶ FC-SW-3, Revision 6.6 (ANSI INCITS 384-2004) ▶ FC-SW-4, Revision 7.5 (ANSI INCITS 418-2006) ▶ FC-SW-5, Revision 8.5 (ANSI INCITS 461-2010) ▶ FC-GS-3, Revision 7.01 (ANSI INCITS 348-2001) ▶ FC-GS-4, Revision 7.91 (ANSI INCITS 387-2004) ▶ FC-GS-5, Revision 8.51 (ANSI INCITS 427-2007) ▶ FC-GS-6, Revision 9.4 (ANSI INCITS 463-2010) ▶ FCP, Revision 12 (ANSI INCITS 269-1996) ▶ FCP-2, Revision 8 (ANSI INCITS 350-2003) ▶ FCP-3, Revision 4 (ANSI INCITS 416-2006) ▶ FCP-4, Revision 2b (ANSI INCITS 481-2011) ▶ FC-SB-2, Revision 2.1 (ANSI INCITS 349-2001) ▶ FC-SB-3, Revision 1.6 (ANSI INCITS 374-2003) ▶ FC-SB-3, Amendment 1 (ANSI INCITS 374-2003/AM1-2007) ▶ FC-SB-4, Revision 3.0 (ANSI INCITS 466-2011) ▶ FC-SB-5, Revision 2.00 (ANSI INCITS 485-2014) ▶ FC-BB-6, Revision 2.00 (ANSI INCITS 509-2014) ▶ FC-BB-2, Revision 6.0 (ANSI INCITS 372-2003) ▶ FC-BB-3, Revision 6.8 (ANSI INCITS 414-2006) ▶ FC-BB-4, Revision 2.7 (ANSI INCITS 419-2008) ▶ FC-BB-5, Revision 2.0 (ANSI INCITS 462-2010) ▶ FC-VI, Revision 1.84 (ANSI INCITS 357-2002) ▶ FC-SP, Revision 1.8 (ANSI INCITS 426-2007) ▶ FC-SP-2, Revision 2.71 (ANSI INCITS 496-2012) ▶ FAIS, Revision 1.03 (ANSI INCITS 432-2007) ▶ FAIS-2, Revision 2.23 (ANSI INCITS 449-2008) ▶ FC-IFR, Revision 1.06 (ANSI INCITS 475-2011) ▶ FC-FLA, Revision 2.7 (INCITS TR-20-1998) ▶ FC-PLDA, Revision 2.1 (INCITS TR-19-1998) ▶ FC-Tape, Revision 1.17 (INCITS TR-24-1999) ▶ FC-MI, Revision 1.92 (INCITS TR-30-2002) ▶ FC-MI-2, Revision 2.6 (INCITS TR-39-2005) ▶ FC-MI-3, Revision 1.03 (INCITS TR-48-2012) |

| Feature | Description |
|-------------------------------|--|
| Protocols (continued) | <ul style="list-style-type: none"> ▶ FC-DA, Revision 3.1 (INCITS TR-36-2004) ▶ FC-DA-2, Revision 1.06 (INCITS TR-49-2012) ▶ FC-MSQS, Revision 3.2 (INCITS TR-46-2011) ▶ Fibre Channel classes of service: Class 2, Class 3, and Class F ▶ Fibre Channel standard port types: E, F, FL, and B ▶ Fibre Channel enhanced port types: SD, ST, and TE ▶ IEEE 802.1Qbb-2011: Priority-based flow control (PFC) ▶ IEEE 802.3db-2011: MAC address control frame for priority-based flow control ▶ IEEE 802.1Qaz-2011: Enhanced transmission selection for bandwidth sharing between traffic classes (ETS and DCBX) ▶ IP over Fibre Channel (RFC 2625) ▶ IPv6, IPv4, and Address Resolution Protocol (ARP) over Fibre Channel (RFC 4338) ▶ Extensive IETF-standards-based TCP/IP, SNMPv3, and remote monitoring (RMON) MIBs |
| Chassis slot configuration | <ul style="list-style-type: none"> ▶ Line-card slots: 16 ▶ Supervisor slots: 2 ▶ Crossbar switching fabric slots: 6 ▶ Fan trays: 3 fan trays at the back of the chassis ▶ Power supply bays: 16 |
| Performance and scalability | <ul style="list-style-type: none"> ▶ Up to 48-Tbps front-panel Fibre Channel switching bandwidth ▶ Supported Fibre Channel port speeds: <ul style="list-style-type: none"> – 4/8-Gbps autosensing, optionally configurable – 4/8/16 Gbps autosensing, optionally configurable – 8/16/32-Gbps autosensing, optionally configurable ▶ Buffer credits: 48-port line-rate 32-Gbps Fibre Channel module <ul style="list-style-type: none"> – Default credits per port: 500 – With Enterprise license, 8300 shared among a single port group of 16 ports ▶ Ports per chassis (one of the following): Up to 768 4/8 Gbps, 4/8/16 Gbps, 8/16/32 Gbps Fibre Channel ▶ Ports per rack: Up to 1152 2/4/8 Gbps, 4/8/16 Gbps, or 10 Gbps Fibre Channel ports ▶ Port channel: Up to 16 ports (the channel can span any speed-matched port on any module in the chassis) |
| Features and functions | |
| Fabric services | <ul style="list-style-type: none"> ▶ Name server ▶ Registered State Change Notification (RSCN) ▶ Login services ▶ Fabric configuration server (FCS) ▶ Broadcast ▶ In-order delivery |
| Advanced functions | <ul style="list-style-type: none"> ▶ VSAN ▶ IVR ▶ PortChannel with multipath load balancing ▶ QoS: flow- and zone-based ▶ N-port ID virtualization |

| Feature | Description |
|---------------------------------------|--|
| Diagnostics and troubleshooting tools | <ul style="list-style-type: none"> ▶ POST diagnostics ▶ Online diagnostics ▶ Internal port loopbacks ▶ SPAN and RSPAN ▶ Fibre Channel traceroute ▶ Fibre Channel ping ▶ Fibre Channel debug ▶ Fabric Analyzer ▶ Syslog ▶ Online system health ▶ Port-level statistics ▶ Real-Time Protocol Debug |
| Network security | <ul style="list-style-type: none"> ▶ VSANs ▶ ACLs ▶ Per-VSAN RBAC ▶ Fibre Channel zoning: <ul style="list-style-type: none"> – N-port Worldwide Name (WWN) – N-port FC-ID – Fx-port WWN – Fx-port WWN and interface index – Fx-port domain ID and interface index – Fx-port domain ID and port number ▶ FC-SP: <ul style="list-style-type: none"> – DH-CHAP switch-switch authentication – DH-CHAP host-switch authentication ▶ Port security and fabric binding ▶ Management access: <ul style="list-style-type: none"> – SSHv2 implementing Advanced Encryption Standard (AES) – SNMPv3 implementing AES – SFTP ▶ TrustSec Fibre Channel link encryption |
| Serviceability | <ul style="list-style-type: none"> ▶ Configuration file management ▶ Nondisruptive software upgrades for Fibre Channel interfaces ▶ Call Home ▶ Power-management LEDs ▶ Port beaconing ▶ System LEDs ▶ SNMP traps for alerts ▶ Network boot |

| Feature | Description |
|------------------------------|---|
| Reliability and availability | <ul style="list-style-type: none"> ▶ Online, nondisruptive software upgrades ▶ Stateful nondisruptive supervisor module failover ▶ Hot-swappable redundant supervisor modules ▶ Hot-swappable redundant fabric modules ▶ Hot-swappable 2 N redundant power ▶ Hot-swappable fan trays with integrated temperature and power management ▶ Hot-swappable Enhanced Small Form-Factor Pluggable (SFP+) optics (2/4/8/10/16 Gbps Fibre Channel and 10-Gigabit Ethernet) ▶ Hot-swappable switching modules ▶ Stateful process restart ▶ Any module, any port configuration for port channels ▶ Fabric-based multipathing ▶ Per-VSAN fabric services ▶ Online diagnostics ▶ Port tracking ▶ Virtual Routing Redundancy Protocol (VRRP) for management |
| Network management | <ul style="list-style-type: none"> ▶ Access methods through the Supervisor-1E Module: <ul style="list-style-type: none"> – Out-of-band 10/100/1000 Ethernet port – RS-232 serial console port – In-band IP over Fibre Channel ▶ Access methods through the Fibre Channel switching module ▶ Access protocols: <ul style="list-style-type: none"> – CLI using console and Ethernet ports – SNMPv3 using Ethernet port and in-band IP over Fibre Channel access ▶ Distributed device alias service ▶ Network security: <ul style="list-style-type: none"> – Per-VSAN RBAC using RADIUS-based and TACACS+-based authentication, authorization, and accounting (AAA) functions – SFTP – SSHv2 implementing AES – SNMPv3 implementing AES ▶ Management applications: <ul style="list-style-type: none"> – Family CLI – DCNM |
| Programming interface | <ul style="list-style-type: none"> ▶ REST API-based NXAPI ▶ Scriptable CLI ▶ DCNM web services API ▶ DCNM GUI |

| Feature | Description |
|--------------------------|---|
| Approvals and compliance | <ul style="list-style-type: none"> ▶ Safety compliance: <ul style="list-style-type: none"> – CE Marking – UL 60950 – CAN/CSA-C22.2 No. 60950 – EN 60950 – IEC 60950 – AS/NZS 3260 – IEC60825 – EN60825 – 21 CFR 1040 ▶ EMC compliance: <ul style="list-style-type: none"> – FCC Part 15 (CFR 47) Class A – ICES-003 Class A – EN 55022 Class A – CISPR 22 Class A – AS/NZS 3548 Class A – VCCI Class A – EN 55024 – EN 50082-1 – EN 61000-6-1 – EN 61000-3-2 – EN 61000-3-3 |

The switching capability per fabric is listed in Table 4.

Table 4 Switching capability per fabric

| Number of fabric cards | Front-Panel Fibre Channel bandwidth per slot |
|------------------------|--|
| 1 | 256 Gbps |
| 2 | 512 Gbps |
| 3 | 768 Gbps |
| 4 | 1024 Gbps |
| 5 | 1280 Gbps |
| 6 | 1536 Gbps |

The physical, electrical, and environmental specifications are listed in Table 5.

Table 5 Physical, electrical, and environmental specifications

| Item | Description |
|---------------------------------|---|
| Power and cooling | <ul style="list-style-type: none"> ▶ Power supplies (3000 W ac): <ul style="list-style-type: none"> – Input: 100 - 240 V ac nominal ($\pm 10\%$ for full range), 16 A nominal, 50 - 60 Hz nominal (± 3 Hz for full range) – Output: 1451 W 50 V $\pm 4\%$/28 A, 3.4 V $\pm 4\%$/15 A (100 - 120 V ac input), 3051 W 50 V $\pm 4\%$/60 A, and 3.4 V $\pm 4\%$/15 A (200 - 240 V ac input) ▶ Air flow: IBM Storage Networking SAN768C-6 provides 30 - 100 cubic feet per minute (CFM) total flow through each line-card slot, depending on the line-card type and fan-speed setting. <p>With IBM Storage Networking SAN768C-6 using front-to-back cold-aisle and hot-aisle air flow, IBM advises that you maintain a minimum air space of 17.78 cm (7 inches) between walls, such as in a cabinet, on the sides, and on the top and bottom of the chassis. The chassis front air vents need a clearance of 30.48 cm (12 inches), and the back air vents need a clearance of 91.44 cm (36 inches) from a solid obstruction, such as a solid wall.</p> |
| Environmental | <ul style="list-style-type: none"> ▶ Temperature, ambient operating: 0 - 40°C (32 - 104°F) ▶ Temperature, ambient nonoperating, and storage: -40 - 70°C (-40 - 158°F) ▶ Relative humidity, ambient (noncondensing) operating: 10 - 90% ▶ Relative humidity, ambient (noncondensing) nonoperating and storage: 10 - 95% ▶ Altitude, operating: -60 - 2000 m (-197 - 6500 ft.) |
| Physical dimensions (H x W x D) | <ul style="list-style-type: none"> ▶ Chassis dimensions (26 rack units [26RU]): 114.9 x 43.9 x 88.9 cm (45.25 x 17.3 x 35 in.) ▶ 48-Port 32-Gbps Fibre Channel Switching Module: 4.4 x 40.39 x 55.37 cm (1.75 x 15.9 x 21.8 in.) ▶ Power supply (3000 W ac): 55.98 x 10.03 x 4.06 cm (22.04 x 3.95 x 1.6 in.) ▶ Fabric-1 module: 82.3 x 5.13 x 25.96 cm (32.40 x 2.02 x 10.22 in.) ▶ Supervisor-1E module: 5.18 x 20.17 x 55.5 cm (2.04 x 7.94 x 21.85 in.) ▶ Fan tray: 91.87 x 13.08 x 4.75 cm (36.17 x 5.15 x 1.87 in.) ▶ SFP+: 1.25 x 1.36 x 5.65 cm (0.49 x 0.54 x 2.22 in.) |
| Weight | <ul style="list-style-type: none"> ▶ Chassis (includes fans): 136 kg (300 lb) ▶ 48-port 32 Gbps Fibre Channel line card: 7.94 kg (17.5 lb) ▶ Power supply (3000 W ac): 2.7 kg (6 lb) ▶ Fabric-1 module: 9.07 kg (20 lb) ▶ Supervisor-1E module: 3.86 kg (8.5 lb) ▶ Fan tray: 5.76 kg (12.7 lb) ▶ Supervisor blank cover: 0.5 kg (1.1 lb) ▶ Line-card blank cover: 2.04 kg (4.5 lb) |

Specifications for the 24/10-Port SAN Extension Module

Table 6 lists the specifications for the 24/10-Port SAN Extension Module.

Table 6 Specifications for the 24/10-Port SAN Extension Module

| Item | Description |
|------------------------|--|
| Product compatibility | IBM Storage Networking c-type family |
| Software compatibility | NX-OS Software 8.1(1b) |
| Protocols | Fibre Channel standards: <ul style="list-style-type: none"> ▶ FC-PH, Revision 4.3 (ANSI INCITS 230-1994) ▶ FC-PH, Amendment 1 (ANSI INCITS 230-1994/AM1-1996) ▶ FC-PH, Amendment 2 (ANSI INCITS 230-1994/AM2-1999) ▶ FC-PH-2, Revision 7.4 (ANSI INCITS 297-1997) ▶ FC-PH-3, Revision 9.4 (ANSI INCITS 303-1998) ▶ FC-PI, Revision 13 (ANSI INCITS 352-2002) ▶ FC-PI-2, Revision 10 (ANSI INCITS 404-2006) ▶ FC-PI-3, Revision 4 (ANSI INCITS 460-2011) ▶ FC-PI-4, Revision 8 (ANSI INCITS 450-2008) ▶ FC-PI-5, Revision 6 (ANSI INCITS 479-2011) ▶ FC-FS, Revision 1.9 (ANSI INCITS 373-2003) ▶ FC-FS-2, Revision 1.01 (ANSI INCITS 424-2007) ▶ FC-FS-2, Amendment 1 (ANSI INCITS 424-2007/AM1-2007) ▶ FC-FS-3, Revision 1.11 (ANSI INCITS 470-2011) ▶ FC-LS, Revision 1.62 (ANSI INCITS 433-2007) ▶ FC-LS-2, Revision 2.21 (ANSI INCITS 477-2011) ▶ FC-SW-2, Revision 5.3 (ANSI INCITS 355-2001) ▶ FC-SW-3, Revision 6.6 (ANSI INCITS 384-2004) ▶ FC-SW-4, Revision 7.5 (ANSI INCITS 418-2006) ▶ FC-SW-5, Revision 8.5 (ANSI INCITS 461-2010) ▶ FC-GS-3, Revision 7.01 (ANSI INCITS 348-2001) ▶ FC-GS-4, Revision 7.91 (ANSI INCITS 387-2004) ▶ FC-GS-5, Revision 8.51 (ANSI INCITS 427-2007) ▶ FC-GS-6, Revision 9.4 (ANSI INCITS 463-2010) ▶ FCP, Revision 12 (ANSI INCITS 269-1996) ▶ FCP-2, Revision 8 (ANSI INCITS 350-2003) ▶ FCP-3, Revision 4 (ANSI INCITS 416-2006) ▶ FCP-4, Revision 2b (ANSI INCITS 481-2011) ▶ FC-SB-2, Revision 2.1 (ANSI INCITS 349-2001) ▶ FC-SB-3, Revision 1.6 (ANSI INCITS 374-2003) ▶ FC-SB-3, Amendment 1 (ANSI INCITS 374-2003/AM1-2007) ▶ FC-SB-4, Revision 3.0 (ANSI INCITS 466-2011) ▶ FC-SB-5, Revision 2.00 (ANSI INCITS 485-2014) ▶ FC-BB-6, Revision 2.00 (ANSI INCITS 509-2014) ▶ FC-BB-2, Revision 6.0 (ANSI INCITS 372-2003) ▶ FC-BB-3, Revision 6.8 (ANSI INCITS 414-2006) ▶ FC-BB-4, Revision 2.7 (ANSI INCITS 419-2008) ▶ FC-BB-5, Revision 2.0 (ANSI INCITS 462-2010) ▶ FC-VI, Revision 1.84 (ANSI INCITS 357-2002) ▶ FC-SP, Revision 1.8 (ANSI INCITS 426-2007) ▶ FC-SP-2, Revision 2.71 (ANSI INCITS 496-2012) ▶ FAIS, Revision 1.03 (ANSI INCITS 432-2007) ▶ FAIS-2, Revision 2.23 (ANSI INCITS 449-2008) ▶ FC-IFR, Revision 1.06 (ANSI INCITS 475-2011) ▶ FC-FLA, Revision 2.7 (INCITS TR-20-1998) |

| Item | Description |
|-------------------------|---|
| Protocols (continued) | <ul style="list-style-type: none"> ▶ FC-PLDA, Revision 2.1 (INCITS TR-19-1998) ▶ FC-Tape, Revision 1.17 (INCITS TR-24-1999) ▶ FC-MI, Revision 1.92 (INCITS TR-30-2002) ▶ FC-MI-2, Revision 2.6 (INCITS TR-39-2005) ▶ FC-MI-3, Revision 1.03 (INCITS TR-48-2012) ▶ FC-DA, Revision 3.1 (INCITS TR-36-2004) ▶ FC-DA-2, Revision 1.06 (INCITS TR-49-2012) ▶ FC-MSQS, Revision 3.2 (INCITS TR-46-2011) ▶ Fibre Channel classes of service: Class 2, Class 3, and Class F ▶ Fibre Channel standard port types: E, F, FL, and B ▶ Fibre Channel enhanced port types: SD, ST, and TE ▶ IP over Fibre Channel (RFC 2625) ▶ IPv6, IPv4, and Address Resolution Protocol (ARP) over Fibre Channel (RFC 4338) ▶ Extensive IETF-standards based TCP/IP, SNMPv3, and remote monitoring (RMON) MIBs <p>IP standards:</p> <ul style="list-style-type: none"> ▶ RFC 791 IPv4 ▶ RFC 793 and 1323 TCP ▶ RFC 894 IP/Ethernet ▶ RFC 1041 IP/802 ▶ RFC 792, 950, and 1256 Internet Control Message Protocol (ICMP) ▶ RFC 1323 TCP performance enhancements ▶ RFC 2338 Virtual Router Redundancy Protocol (VRRP) ▶ RFC 2460 and 4291 IPv6 ▶ RFC 2463 ICMPv6 ▶ RFC 2461 and 2462 IPv6 neighbor discovery and stateless autoconfiguration ▶ RFC 2464 IPv6/Ethernet ▶ RFC 3643 and 3821 FCIP <p>Ethernet standards:</p> <ul style="list-style-type: none"> ▶ IEEE 802.3z Gigabit Ethernet ▶ IEEE 802.1Q VLAN <p>IPsec standards:</p> <ul style="list-style-type: none"> ▶ RFC 2401 Security Architecture for IP ▶ RFC 2403 and 2404 Hash Message Authentication Code (HMAC) ▶ RFC 2405, 2406, and 2451 IP Encapsulating Security Payload (ESP) ▶ RFC 2407 and 2408 Internet Security Association and Key Management Protocol (ISAKMP) ▶ RFC 2412 OAKLEY Key Determination Protocol ▶ RFC 3566, 3602, and 3686 AES <p>Internet Key Exchange (IKE) standards:</p> <ul style="list-style-type: none"> ▶ RFC 2409 IKEv1 ▶ IKEv2, draft |
| Cards, ports, and slots | 24 x fixed 2/4/8/10/16-Gbps Fibre Channel ports, 8 x 1/10 Gigabit Ethernet ports |

| Item | Description |
|---------------------------------------|---|
| Features and Functions | |
| Fabric services | <ul style="list-style-type: none"> ▶ Name server ▶ Registered state change notification (RSCN) ▶ Login services ▶ Fabric Configuration Server (FCS) ▶ Private loop ▶ Public loop ▶ Translative loop ▶ Broadcast ▶ In-order delivery |
| Advanced functions | <ul style="list-style-type: none"> ▶ VSAN ▶ IVR ▶ Port channel with multipath load balancing ▶ Flow-based and zone-based QoS ▶ Hardware-based compression for MAN and WAN data ▶ Hardware-based encryption ▶ Hardware-based data integrity ▶ FCIP disk write acceleration ▶ FCIP tape read and write acceleration |
| Diagnostics and troubleshooting tools | <ul style="list-style-type: none"> ▶ POST diagnostics ▶ Online diagnostics ▶ Internal port loopbacks ▶ SPAN and remote SPAN ▶ Fibre Channel Traceroute ▶ Fibre Channel Ping ▶ Fibre Channel Debug ▶ Fabric Analyzer ▶ Syslog ▶ Online system health ▶ Port-level statistics ▶ Real-Time Protocol (RTP) debug |
| Network security | <ul style="list-style-type: none"> ▶ VSANs ▶ ACLs ▶ Per-VSAN RBAC ▶ Fibre Channel zoning: <ul style="list-style-type: none"> – N-port worldwide name (WWN) – N-port FC-ID – Fx-port WWN – Fx-port WWN and interface index – Fx-port domain ID and interface index – Fx-port domain ID and port number – Logical unit number (LUN) – Read-only – Broadcast ▶ FC-SP: <ul style="list-style-type: none"> – DH-CHAP switch-to-switch authentication – DH-CHAP host-to-switch authentication ▶ Port security and fabric binding ▶ IPsec for FCIP ▶ IKEv1 and v2 ▶ Management access: <ul style="list-style-type: none"> – SSH v2 implementing AES – SNMPv3 implementing AES – SFTP |

| Item | Description |
|------------------------------|--|
| Serviceability | <ul style="list-style-type: none"> ▶ Configuration file management ▶ Nondisruptive software upgrades for Fibre Channel interfaces ▶ Call Home ▶ Power-management LEDs ▶ Port beaconing ▶ System LED ▶ SNMP traps for alerts ▶ Network boot |
| Performance | <ul style="list-style-type: none"> ▶ Port speed: Fibre Channel 2/4/8/10/16 Gbps, FCIP 1/10/40 Gigabit Ethernet ▶ Port channels: Up to 16 FCIP links ▶ FCIP tunnels: Up to 4 per port |
| Reliability and availability | <ul style="list-style-type: none"> ▶ Hot-swappable module ▶ Hot-swappable SFP optics ▶ Online diagnostics ▶ Stateful process restart ▶ Nondisruptive supervisor failover ▶ Any module, any port configuration for port channels ▶ Fabric-based multipathing ▶ Per-VSAN fabric services ▶ Port tracking ▶ VRRP for management and FCIP |
| Network management | <p>Access methods through Supervisor Module:</p> <ul style="list-style-type: none"> ▶ Out-of-band 10/100/1000 Ethernet port (Supervisor-1 Module) ▶ Out-of-band 10/100/1000 Ethernet port (Supervisor-2 Module) ▶ RS-232 serial console port (RJ45 form factor) ▶ In-band IP-over-Fibre Channel <p>Access protocols:</p> <ul style="list-style-type: none"> ▶ Command-line interface (CLI) through console and Ethernet ports ▶ SNMPv3 through Ethernet port and in-band IP-over-Fibre Channel access ▶ Storage Networking Industry Association (SNIA) Storage Management Initiative Specification (SMI-S) <p>Distributed device alias service</p> <p>Network security:</p> <ul style="list-style-type: none"> ▶ Per-VSAN RBAC using RADIUS- and TACACS+-based authentication, authorization, and accounting (AAA) functions ▶ SFTP ▶ SSHv2 implementing AES ▶ SNMPv3 implementing AES <p>Management applications:</p> <ul style="list-style-type: none"> ▶ CLI ▶ Data Center Network Manager ▶ Device Manager |
| Programming interfaces | <ul style="list-style-type: none"> ▶ Fabric Manager GUI ▶ Device Manager GUI |

| Item | Description |
|--------------------------|--|
| Environmental | <ul style="list-style-type: none"> ▶ Temperature, ambient operating: 0 - 40°C (32 - 104°F) ▶ Temperature, ambient nonoperating and storage: -40 - 70°C (-40 - 158°F) ▶ Relative humidity, ambient (noncondensing) operating: 5 - 90% ▶ Relative humidity, ambient (noncondensing) nonoperating and storage: 5 - 95% ▶ Altitude, operating: -60 - 2000m (-197 - 6500 ft.) |
| Physical dimensions | <ul style="list-style-type: none"> ▶ Dimensions (H x W x D): 4.4 x 40.39 x 55.37 cm (1.75 x 15.9 x 21.8 in.): Occupies one slot in a IBM Storage Networking c-type family chassis ▶ Weight: 7.71 kg (17 lb) |
| Approvals and compliance | <p>Safety compliance:</p> <ul style="list-style-type: none"> ▶ CE Marking ▶ UL 60950 ▶ CAN/CSA-C22.2 No. 60950 ▶ EN 60950 ▶ IEC 60950 ▶ TS 001 ▶ AS/NZS 3260 ▶ IEC60825 ▶ EN60825 ▶ 21 CFR 1040 <p>EMC compliance:</p> <ul style="list-style-type: none"> ▶ FCC Part 15 (CFR 47) Class A ▶ ICES-003 Class A ▶ EN 55022 Class A ▶ CISPR 22 Class A ▶ AS/NZS 3548 Class A ▶ VCCI Class A ▶ EN 55024 ▶ EN 50082-1 ▶ EN 61000-6-1 ▶ EN 61000-3-2 ▶ EN 61000-3-3 |

Specifications for the 48-Port 32-Gbps Fibre Channel Switching Module

Table 7 lists the specifications for the 48-Port 32-Gbps Fibre Channel Switching Module.

Table 7 Specifications for the 48-Port 32-Gbps Fibre Channel Switching Modules

| Item | Description |
|------------------------|--|
| Product compatibility | IBM Storage Networking c-type family Directors |
| Software compatibility | NX-OS Software Release NX-OS 8.1(1b) |
| Protocols | <ul style="list-style-type: none"> ▶ Fibre Channel standards: <ul style="list-style-type: none"> – FC-PH, Revision 4.3 (ANSI INCITS 230-1994) – FC-PH, Amendment 1 (ANSI INCITS 230-1994/AM1-1996) – FC-PH, Amendment 2 (ANSI INCITS 230-1994/AM2-1999) – FC-PH-2, Revision 7.4 (ANSI INCITS 297-1997) – FC-PH-3, Revision 9.4 (ANSI INCITS 303-1998) – FC-PI, Revision 13 (ANSI INCITS 352-2002) – FC-PI-2, Revision 10 (ANSI INCITS 404-2006) – FC-PI-3, Revision 4 (ANSI INCITS 460-2011) – FC-PI-4, Revision 8 (ANSI INCITS 450-2008) – FC-PI-5, Revision 6 (ANSI INCITS 479-2011) – FC-FS, Revision 1.9 (ANSI INCITS 373-2003) – FC-FS-2, Revision 1.01 (ANSI INCITS 424-2007) – FC-FS-2, Amendment 1 (ANSI INCITS 424-2007/AM1-2007) – FC-FS-3, Revision 1.11 (ANSI INCITS 470-2011) – FC-LS, Revision 1.62 (ANSI INCITS 433-2007) – FC-LS-2, Revision 2.21 (ANSI INCITS 477-2011) – FC-SW-2, Revision 5.3 (ANSI INCITS 355-2001) – FC-SW-3, Revision 6.6 (ANSI INCITS 384-2004) – FC-SW-4, Revision 7.5 (ANSI INCITS 418-2006) – FC-SW-5, Revision 8.5 (ANSI INCITS 461-2010) – FC-GS-3, Revision 7.01 (ANSI INCITS 348-2001) – FC-GS-4, Revision 7.91 (ANSI INCITS 387-2004) – FC-GS-5, Revision 8.51 (ANSI INCITS 427-2007) – FC-GS-6, Revision 9.4 (ANSI INCITS 463-2010) – FCP, Revision 12 (ANSI INCITS 269-1996) |

| Item | Description |
|-------------------------|---|
| Protocols (continued) | <ul style="list-style-type: none"> ▶ Fibre Channel standards (continued): <ul style="list-style-type: none"> – FCP-2, Revision 8 (ANSI INCITS 350-2003) – FCP-3, Revision 4 (ANSI INCITS 416-2006) – FCP-4, Revision 2b (ANSI INCITS 481-2011) – FC-SB-2, Revision 2.1 (ANSI INCITS 349-2001) – FC-SB-3, Revision 1.6 (ANSI INCITS 374-2003) – FC-SB-3, Amendment 1 (ANSI INCITS 374-2003/AM1-2007) – FC-SB-4, Revision 3.0 (ANSI INCITS 466-2011) – FC-SB-5, Revision 2.00 (ANSI INCITS 485-2014) – FC-BB-6, Revision 2.00 (ANSI INCITS 509-2014) – FC-BB-2, Revision 6.0 (ANSI INCITS 372-2003) – FC-BB-3, Revision 6.8 (ANSI INCITS 414-2006) – FC-BB-4, Revision 2.7 (ANSI INCITS 419-2008) – FC-BB-5, Revision 2.0 (ANSI INCITS 462-2010) – FC-VI, Revision 1.84 (ANSI INCITS 357-2002) – FC-SP, Revision 1.8 (ANSI INCITS 426-2007) – FC-SP-2, Revision 2.71 (ANSI INCITS 496-2012) – FAIS, Revision 1.03 (ANSI INCITS 432-2007) – FAIS-2, Revision 2.23 (ANSI INCITS 449-2008) – FC-IFR, Revision 1.06 (ANSI INCITS 475-2011) – FC-FLA, Revision 2.7 (INCITS TR-20-1998) – FC-PLDA, Revision 2.1 (INCITS TR-19-1998) – FC-Tape, Revision 1.17 (INCITS TR-24-1999) – FC-MI, Revision 1.92 (INCITS TR-30-2002) – FC-MI-2, Revision 2.6 (INCITS TR-39-2005) – FC-MI-3, Revision 1.03 (INCITS TR-48-2012) – FC-DA, Revision 3.1 (INCITS TR-36-2004) – FC-DA-2, Revision 1.06 (INCITS TR-49-2012) – FC-MSQS, Revision 3.2 (INCITS TR-46-2011) ▶ Fibre Channel classes of service: Class 2, Class 3, and Class F ▶ Fibre Channel standard port types: E, F, FL, and B ▶ Fibre Channel enhanced port types: SD, ST, and TE |
| Cards, ports, and slots | <ul style="list-style-type: none"> ▶ 48 autosensing 4/8-Gbps or 4/8/16-Gbps or 8/16/32-Gbps Fibre Channel ports ▶ Can be used on any payload slot of the IBM Storage Networking c-type family directors |
| Features and functions | |
| Fabric services | <ul style="list-style-type: none"> ▶ Name server ▶ Registered state-change notification (RSCN) ▶ Login services ▶ Fabric configuration server (FCS) ▶ Public loop ▶ Broadcast ▶ In-order delivery |
| Advanced functions | <ul style="list-style-type: none"> ▶ VSAN ▶ IVR ▶ Port channel with multipath load balancing ▶ Flow-based and zone-based QoS ▶ N-port ID virtualization (NPIV) ▶ Inline analytics |

| Item | Description |
|---------------------------------------|---|
| Diagnostics and troubleshooting tools | <ul style="list-style-type: none"> ▶ POST diagnostics ▶ Online diagnostics ▶ Internal port loopbacks ▶ SPAN and RSPAN ▶ Fibre Channel traceroute ▶ Fibre Channel ping ▶ Fibre Channel debug ▶ Fabric Analyzer ▶ Syslog ▶ Online system health ▶ Port-level statistics ▶ Real-time protocol debug ▶ E-port and F-port diagnostics |
| Network security | <ul style="list-style-type: none"> ▶ VSANs ▶ ACLs ▶ Per-VSAN RBAC ▶ Fibre Channel zoning: <ul style="list-style-type: none"> – N-port Worldwide Name (WWN) – N-port Fibre Channel ID (FC-ID) – Fx-port WWN – Fx-port WWN and interface index – Fx-port domain ID and interface index – Fx-port domain ID and port number – LUN ▶ FC-SP:^a <ul style="list-style-type: none"> – DH-CHAP switch-to-switch authentication – DH-CHAP host-to-switch authentication ▶ Port security and fabric binding ▶ Management access: <ul style="list-style-type: none"> – SSHv2 implementing AES – SNMPv3 implementing AES – SFTP ▶ TrustSec1 Fibre Channel link-level encryption: <ul style="list-style-type: none"> – SSHv2 implementing AES |
| Serviceability | <ul style="list-style-type: none"> ▶ Configuration file management ▶ Nondisruptive software upgrades for Fibre Channel interfaces ▶ Call Home ▶ Power-management LEDs ▶ Port beaconing ▶ System LED ▶ SNMP traps for alerts ▶ Network boot |
| Performance | <ul style="list-style-type: none"> ▶ Port speed: 4/8-Gbps, 4/8/16-Gbps, and 8/16/32-Gbps autosensing Fibre Channel ▶ Buffer credits: <ul style="list-style-type: none"> – Default credits per port: 500 – With Enterprise license <ul style="list-style-type: none"> • 8300 shared among a single port group of 16 ports • 8191 maximum credits per port ▶ Port channel: Up to 16 ports |

| Item | Description |
|------------------------------|---|
| Reliability and availability | <ul style="list-style-type: none"> ▶ Hot-swappable module ▶ Hot-swappable SFP+ transceivers ▶ Online diagnostics ▶ Stateful process restart ▶ Nondisruptive supervisor failover ▶ Any-module, any-port configuration for port channels ▶ Fabric-based multipathing ▶ Per-VSAN fabric services ▶ Port tracking ▶ Virtual Routing Redundancy Protocol (VRRP) for management |
| Network management | <ul style="list-style-type: none"> ▶ Access methods through the Supervisor-1 Module: <ul style="list-style-type: none"> – Out-of-band 10/100/1000 Ethernet port (Supervisor-1) – RS-232 serial console port – In-band IP over Fibre Channel ▶ Access methods through Fibre Channel switching module: <ul style="list-style-type: none"> – In-band FICON Control Unit Port (CUP) over any IBM System Z FICON channel ▶ Access protocols: <ul style="list-style-type: none"> – Command-line interface (CLI) through console and Ethernet ports – SNMPv3 through Ethernet port and in-band IP over Fibre Channel access – FICON CUP ▶ Distributed Device Alias service ▶ Network security: <ul style="list-style-type: none"> – Per-VSAN RBAC using RADIUS- and TACACS+-based authentication, authorization, and accounting (AAA) functions – SFTP – SSHv2 implementing AES – SNMPv3 implementing AES ▶ Management applications: <ul style="list-style-type: none"> – CLI – Fabric Manager – Device Manager |
| Programming interfaces | <ul style="list-style-type: none"> ▶ Scriptable CLI ▶ DCNM web services API ▶ DCNM GUI ▶ Representational state transfer (REST) API |
| Environmental | <ul style="list-style-type: none"> ▶ Temperature, ambient operating: 0 - 40°C (32 - 104°F) ▶ Temperature, ambient nonoperating and storage: -40 - 70°C (-40 - 158°F) ▶ Relative humidity, ambient (noncondensing) operating: 10 - 90% ▶ Relative humidity, ambient (noncondensing) nonoperating and storage: 10 - 95% ▶ Altitude, operating: -60 - 2000m (-197 - 6500 ft) |
| Physical dimensions | <ul style="list-style-type: none"> ▶ Dimensions (H x W x D): 4.4 x 40.39 x 55.37 cm (1.75 x 15.9 x 21.8 in.) ▶ Weight: 7.94 kg (17.5 lb) |

| Item | Description |
|--------------------------|--|
| Approvals and compliance | <ul style="list-style-type: none"> ▶ Regulatory compliance: <ul style="list-style-type: none"> – CE Markings per directives 2004/108/EC and 2006/95/EC ▶ Safety compliance: <ul style="list-style-type: none"> – UL 60950-1 Second Edition – CAN/CSA-C22.2 No. 60950-1 Second Edition – EN 60950-1 Second Edition – IEC 60950-1 Second Edition – AS/NZS 60950-1 – GB4943 2001 ▶ EMC compliance: <ul style="list-style-type: none"> – 47CFR Part 15 (CFR 47) Class A – AS/NZS CISPR22 Class A – CISPR22 Class A – EN55022 Class A – ICES003 Class A – VCCI Class A – EN61000-3-2 – EN61000-3-3 – KN22 Class A – CNS13438 Class A – EN55024 – CISPR24 – EN300386 – KN24 |

a. Supported only for 4- and 8-Gbps speeds, 2 Gbps is not supported

Table 8 lists supported optics, media, and transmission distances.

Table 8 Supported optics, media, and transmission distances

| Speed | Media | Distance |
|--|---|--|
| <ul style="list-style-type: none"> ▶ 32-Gbps shortwave LC, SFP+ ▶ 32-Gbps longwave, LC, SFP+ ▶ 16-Gbps shortwave, LC, SFP+ ▶ 16-Gbps longwave, LC, SFP+ ▶ 8-Gbps shortwave, LC, SFP+ ▶ 8-Gbps longwave, LC, SFP+ | <ul style="list-style-type: none"> ▶ 50/125-micron multimode ▶ 9/125-micron single mode ▶ 50/125-micron multimode ▶ 9/125-micron single mode ▶ 50/125-micron multimode ▶ 9/125-micron single mode | <ul style="list-style-type: none"> ▶ 70 m OM3 and 100 m OM4 ▶ 10 km ▶ 100 m OM3 and 125 m OM4 ▶ 10 km ▶ 150m OM3 and 190 m OM4 ▶ 10 km |

Product specifications for the Supervisor-1 Module

Table 9 lists the specifications for the Supervisor-1 Module.

Table 9 Specifications for the Supervisor-1 Module

| Feature | Description |
|------------------------|--|
| Product compatibility | IBM Storage Networking c-type family |
| Software compatibility | NX-OS Software Release 8.1(1b) or later. |

| Feature | Description |
|--------------------------------------|--|
| Interfaces | (1) RS-232 RJ-45 console port (1) 10/100/1000 Ethernet management port (2) USB 2.0 ports |
| Indicators | Status LED System LED Power management LED Active/standby LED |
| Backplane bandwidth | <ul style="list-style-type: none"> ▶ Up to 24 Tbps of FC backplane bandwidth ▶ Up to 384 2/4/8/16 Gbps Full Line Rate autosensing Fibre Channel and 10-Gbps fixed speed ports in a single chassis |
| Chassis slot configuration | Two Supervisor-1 modules are required per system. |
| Fabric services | <ul style="list-style-type: none"> ▶ Name server ▶ Registered State Change Notification (RSCN) ▶ Login services ▶ Fabric Configuration Server (FCS) ▶ Broadcast ▶ In-order delivery |
| Advanced functions | <ul style="list-style-type: none"> ▶ VSAN ▶ IVR ▶ PortChannel with multipath load balancing ▶ QoS-flow-based, zone-based ▶ FCC ▶ N_Port ID virtualization |
| Diagnostic and troubleshooting tools | <ul style="list-style-type: none"> ▶ POST diagnostic tests ▶ Online diagnostic tests ▶ Internal port loopbacks ▶ SPAN and RSPAN ▶ Fibre Channel Traceroute ▶ Fibre Channel Ping ▶ Fibre Channel Debug ▶ Fabric Analyzer ▶ Syslog ▶ Online system health ▶ Port-level statistics ▶ Real-Time Protocol Debug |

| Feature | Description |
|------------------------------|---|
| Network security | <ul style="list-style-type: none"> ▶ VSANs ▶ ACLs ▶ Per-VSAN RBAC ▶ Fibre Channel zoning: <ul style="list-style-type: none"> – N_Port WWN – N_Port FC-ID – Fx_Port WWN – Fx_Port WWN and interface index – Fx_Port domain ID and interface index – Fx_Port domain ID and port number – LUN – Read-only – Broadcast ▶ FC-SP: <ul style="list-style-type: none"> – DH-CHAP switch-switch authentication – DH-CHAP host-switch authentication ▶ Port security and fabric binding ▶ Management access: <ul style="list-style-type: none"> – SSHv2 implementing AES – SNMPv3 implementing AES – SFTP |
| Serviceability | <ul style="list-style-type: none"> ▶ Configuration file management ▶ Nondisruptive software upgrades for Fibre Channel interfaces ▶ Call Home ▶ Power-management LEDs ▶ Port beaconing ▶ System LED ▶ SNMP traps for alerts ▶ Network boot |
| Reliability and availability | <ul style="list-style-type: none"> ▶ Hot-swappable module ▶ Active-active redundancy ▶ Stateful Process Restart ▶ Stateful, nondisruptive supervisor failover ▶ Online, nondisruptive software upgrades ▶ Virtual Routing Redundancy Protocol (VRRP) for management ▶ Per-VSAN fabric services ▶ Power management ▶ Thermal management ▶ Fabric-based multipathing |

| Feature | Description |
|-----------------------|---|
| Network management | <ul style="list-style-type: none"> ▶ Access methods through the Supervisor-1 Module: <ul style="list-style-type: none"> – Out-of-band 10/100/1000 Ethernet port – RS-232 serial console port – In-band IP over Fibre Channel ▶ Access protocols: <ul style="list-style-type: none"> – CLI-using console and Ethernet ports – SNMPv3-using Ethernet port and in-band IP over Fibre Channel access ▶ Distributed Device Alias service ▶ Network security: <ul style="list-style-type: none"> – Per-VSAN role-based access control by using RADIUS-based and TACACS+-based authentication, authorization, and accounting (AAA) functions – SFTP – SSHv2 implementing AES – SNMPv3 implementing AES ▶ Management applications: <ul style="list-style-type: none"> – CLI – Data Center Network Manager |
| Programming interface | <ul style="list-style-type: none"> ▶ Scriptable CLI ▶ Data Center Network Manager web services API ▶ DCNM GUI |
| Physical dimensions | <ul style="list-style-type: none"> ▶ Physical dimensionsDimensions (H x W x D): 5.18 x 19.05 x 55.37 cm (2.04 x 7.5 x 21.8 in.) ▶ Weight: 3.2 kg (7 lb) |

Related information

For more information, see the following documents:

- ▶ IBM Storage Networking SAN50C-R Product Guide, TIPS1359
<http://www.redbooks.ibm.com/abstracts/tips1359.html>
- ▶ IBM Storage Networking SAN384C-6 Product Guide, TIPS1360
<http://www.redbooks.ibm.com/abstracts/tips1360.html>
- ▶ IBM Storage Networking SAN32C-6 Product Guide, TIPS1361
<http://www.redbooks.ibm.com/abstracts/tips1361.html>
- ▶ IBM Storage Networking SAN192C-6 Product Guide, TIPS1362
<http://www.redbooks.ibm.com/abstracts/tips1362.html>
- ▶ IBM Storage Networking SAN768C-6 Product Guide, REDP5513
<http://www.redbooks.ibm.com/abstracts/redp5513.html>
- ▶ IBM Support Fix Central support site (select a product from drop-down menus)
<http://www.ibm.com/support/fixcentral/>
- ▶ IBM System Storage Interoperation Center (SSIC)
<http://www.ibm.com/systems/support/storage/ssic/interoperability.wss>

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