

# White paper

## Fibre channel on BS2000/OSD s series business servers

Fibre Channel is the current standard for host-storage connections in the open systems world. BS2000/OSD business servers, too, have made the transition to the Fibre Channel interface for advanced high-performance peripherals.

On the S servers, Fibre Channel connectivity was introduced at the end of 2002, starting with the S120/S140/S170 models running BS2000/OSD-BC V5.0B. It has since become available for all current S server models and is also standard on the new S175 and S210 servers.

All currently available online and near line peripheral devices for BS2000/OSD servers provide Fibre Channel connectivity, including the recently introduced ETERNUS DX400/DX400 S2/DX8000 disk storage systems. BS2000 LAN connectivity is provided by the HNC, which can be connected to the server via Fibre Channel as of HNC-IV.

High transfer rates and extremely short response times are a hallmark of Fibre Channel connection technology. It enables servers to integrate into an enterprise storage area network (SAN) and therefore also supports server integration into storage consolidation environments on the basis of the most advanced connection standards.



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## Connection technologies for S servers (ESCON, Fibre Channel)

ESCON has been the standard connection technology in the mainframe environment since the second half of the nineties, supporting a maximum device distance of 3 km (9 km with repeaters) and a theoretical maximum transfer rate of 17 MB/s. In practice, effective data rates of up to 16 MB/s are achieved. On BS2000 servers ESCON connections were realized by the type S channel. It is supported by all the business servers of the S line.

FICON (Fibre Connection Channel) was introduced by IBM at the end of 1999.

FICON channels can bridge greater distances than ESCON and support a higher data rate.

FICON technology has to be rated as a proprietary IBM architecture, so there are no plans to introduce peripheral devices with a FICON interface into the BS2000 environment.

The future strategic connection technology for the S-series business servers is Fibre Channel.

Fibre Channel is the current standard for host-storage connections in the open systems world.

The transmission technology and characteristics (optics, connection variants, distances, data rates) of FICON and Fibre Channel are very similar.

Now, Fibre Channel is the standard connection technology for disk and tape peripherals not only on the SX and SQ servers but also on S servers.

Fibre Channel connections can be used with all operating system versions since BS2000/OSD V5.0B and with all current business server models.

Currently the following devices are supported on S servers via Fibre Channel:

Device class	Device	OS support: as of BS2000/OSD-BC	Release date
Disk	Symmetrix 8000 and DMX	V5.0B	December 2002
	Symmetrix DMX-3	V5.0C	December 2005
	Symmetrix DMX-4	V5.0C	Dezember 2007
	Symmetrix VMAX-1	V6.0B	September 2009
	ETERNUS DX400/DX8000	V7.0B	September 2010
Tape	ETERNUS DX400 S2	V7.0B	September 2011
	ETERNUS CS High End (formerly CentricStor)	V5.0C	February 2004
	Scalar 10K and i2000 with LTO-2	V6.0A	January 2005
	Scalar 10K, i2000 and i500 with LTO-3	V6.0B	January 2007
	Scalar 10K, i2000 and i500 with LTO-4	V8.0A	May 2009
Network	Scalar 10K, i6000 and i500 with LTO-5	V8.0A	July - August 2011 <sup>*)</sup>
	HNC-IV	V5.0C	June 2006
	HNC-V	V5.0C	April 2011

<sup>\*)</sup> Release dates of LTO-5 for s series: Scalar i500 in July 2011, Scalar i6k in August 2011, Scalar 10k in September 2011

FC channels on S servers operate at 100 MB/s (1024 Mbit/s). Performance scores of up to 95 MB/s were recorded on S systems with Fiber Channel interface, thus almost reaching the maximum theoretical throughput of 100 MB/s in real-world use (see 'Performance' section below).

## SAN integration of S series business servers

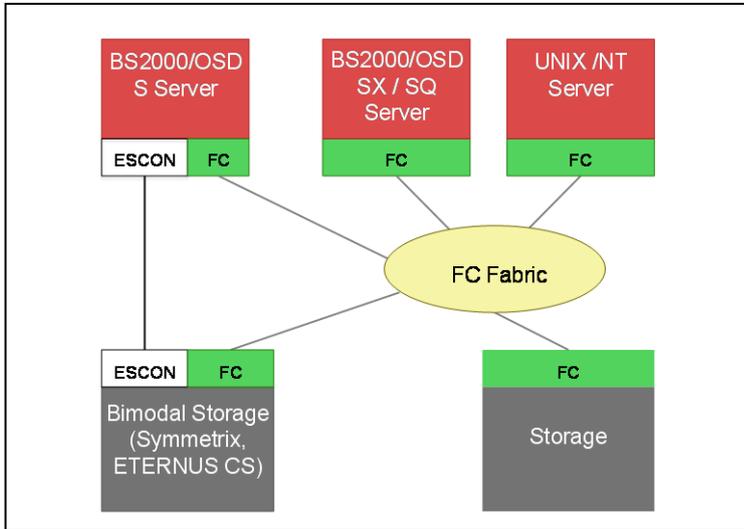
Fibre Channel technology makes a distinction between three types of connection topology: "point to point", "fabric", and "arbitrated loop" topology. A SAN (Storage Area Network) is a networking arrangement between servers and storage systems set up on the basis of one of these topologies. In a fabric topology, dedicated connections are switched between servers and storage systems. A server sees only the storage systems assigned to it. The associated servers and storage systems form so-called zones. The zones are set up (switched) with the aid of switches. This process is called "zoning".

The following figure shows how S servers with /390 architecture can be integrated into a heterogeneous SAN containing SX/SQ and Windows or UNIX system-based servers.

Only fabric topologies are supported in the implementation of the Fibre Channel connection to BS2000/OSD servers with /390 architecture. Most notably, a Fibre Channel switch is required even for 1:1 pairings of S server and storage system. An FC switch is also required in all instances for the ETERNUS CS resp. LTO tape connection.

The only exception is the HNC-IV that can be directly connected to the server's FC channel (without switch).

Connections between channels and controllers by means of switches must be set at the switch (zoning).



## Functional scope of Fibre Channel support on S servers

### ETERNUS DX400/DX400 S2/DX8000 disk subsystems

Since 2010, May, the ETERNUS DX410/DX440 and DX8400/DX8700 storage systems are available for connection on type FC channel of the BS2000/OSD S servers. With the enhanced release of 2010, September, operation under BS2000/OSD-BC V8.0A and V7.0B is possible. The new generation ETERNUS DX400 S2 can be used with BS2000/OSD s series business servers since September 2011.

#### Disk format and disk type

In the ETERNUS DX system, the FBA format D3435 based on a 512-byte block length is supported via the FC interface. The 2K key and NK2 data formats are supported, but not NK4. Connection of ETERNUS DX over ESCON (type S channel) is not possible.

### Symmetrix disk subsystems

Starting with V5.0B, BS2000/OSD-BC supports the connection of Symmetrix disk subsystems to the FC channel of S servers.

#### Disk format and disk type

In the Symmetrix system, the FBA format based on a 512-byte block length is available via the FC interface. Support for the FBA format has been provided for D3435-type Symmetrix disks connected to ESCON (type S channel) in BS2000 since as far back as the release of BS2000/OSD-BC V4.0 (8.99), and it is also supported by means of Repls in BS2000/OSD-BC V2.0/V3.0. The 2K key and NK2 data formats are supported, but not NK4. Device type D3435 (with the 2K key and NK2 data formats) is therefore also used for connection to the FC channel, i.e. the format of a D3435 disk connected to the FC channel is identical to the format of a D3435 disk connected to the type S channel. This means that: D3435 disks that were previously connected to the type S channel can be operated unchanged on the FC channel of the S server following the installation of an FC board in the Symmetrix and recabling.

Compared with the CKD format, the FBA format offers the following benefits:

Up to 34% increase in capacity (depending on file format)

Variable volume size and higher maximum size for volumes (up to 15 GB on the ESCON channel, up to n\*15 GB on the FC channel when using meta volumes on n physical volumes)

Better performance in mixed mainframe and open systems operation

With Symmetrix disks, FBA formatting of BS2000 data when performing a storage consolidation of BS2000 and open systems data in a Symmetrix system also means that no ESP license within the Symmetrix is required (ESP = Enterprise Storage Platform).

#### Migration to the FBA format

When migrating disks from CKD to FBA format, with existing K- or NK2-formatted disks the format can be retained; NK4-formatted disks must be converted to NK2 formatting.

If source disks in K, NK2, NK4 format are converted to K, NK2 target disks with the same allocation unit in each case, no additional conversion measures are necessary. Existing programs and JCL run unchanged. In particular, the data formats PAMKEY, DATA, DATA2K and DATA4K always remain unaffected by the conversion!

The disk migration can either be carried out offline using HSMS or ARCHIVE outside of ongoing production operation, or online using DRV V3.0 or higher during ongoing production operation.

Disk migration from CKD to FBA format should not be confused with PAM key elimination (this is essentially a change to the data format). This is always possible independently. Since Pam key elimination takes up much more time, it is strongly recommended that it not be carried out at the same time as the disk migration.

#### Disk migration using DRV V3.0 or higher

A migration tool integrated into the DRV subsystem enables a data resource residing on disks of the D3490-xx and D34211 types and formatted as K, NK2 and NK4 to be copied onto K or NK2-formatted D3435 disks connected to the type S channel in parallel with production operation.

Target disk can be of larger size than the source disk. (More precisely: The target disk is supported as a 1:1 copy of the source disk; this may result in an initially unusable space occurring at the end of the target disk; see also extension of disks using SPACEOPT as of V3.0.)

Only the switchover to the copy leads to short downtimes (in the minutes range). Following recabling, the copy can be operated unchanged on the FC channel of the S system.

In DRV version 3.0C, the migration tool was expanded to enable the target disk to be connected directly to the FC channel of the S server. This allows direct migration from CKD disks connected to the type S channel to FBA disks connected to the FC channel. Now, new disk subsystems no longer require an ESCON connection for the transfer, thus eliminating conversion times.

The release of DRV V3.0C was effective with the shipment of correction package 1/2005 in May 2005. The current DRV version V3.2 was released in May 2009 with BS2000/OSD-BC V8.0, this version runs as of BS2000/OSD-BC V6.0.

### Migration scenarios Symmetrix and ETERNUS DX

DRV supports the following migration paths:

Symmetrix CKD disk on type S channel -> Symmetrix FBA target disk D3435 on FC channel: via DRV migration tool

Symmetrix CKD disk on type S channel -> ETERNUS DX FBA target disk D3435 on FC channel: via DRV migration tool

Symmetrix FBA disk D3435 on FC channel -> ETERNUS DX FBA target disk D3435 on FC channel: via DRV standard function (equalization)

### Extension of disks using SPACEOPT as of V3.0

In Symmetrix and ETERNUS DX disk subsystems, the size of BS2000 disks can be adjusted to match the size of the LUNs (Logical Units) used to implement them. This adjustment may be necessary after using DRV for a disk migration, which requires the source and target disk to have the same capacity. The function is only available for the D3435 disk format (FBA formatting).

SPACEOPT V3.0 was released along with BS2000/OSD-BC V6.0 in December 2004. The disk extension feature was also made available in December 2004 via a SPACEOPT V2.0C correction version for BS2000/OSD-BC V5.0.

For BS2000/OSD-BC V7.0, there is SPACEOPT V4.0 available, and SPACEOPT V5.0 is offered for BS2000/OSD-BC V8.0.

### System generation with IOGEN

Starting with BS2000/OSD-BC V5.0B, the IOGEN program is used for I/O generation after changes to the hardware configuration, instead of the previous UGEN program. Fibre Channel support on /390 systems was implemented in IOGEN. IOGEN has brought about a multiple increase in the speed of I/O generation. Files containing statements for I/O generation using UGEN V14.0A can also be processed by IOGEN.

### IPL

The IPL procedure on S145, S155, S165, S175, S180, S190, S200 and S210 servers can also be initiated via the FC channel.

### Dynamic I/O configuration changes

The input/output configuration can be changed during online operation on S series servers, i.e. the existing configuration can be extended, modified or reduced without a new IMPL.

This capability to perform configuration changes dynamically is also available for FC channels and the controllers and devices connected to them.

### PAV (Parallel Access Volume)

As an alternative to simple disk access (standard), parallel disk access is supported (PAV = Parallel Access Volume). With Parallel Access Volume (PAV), several device addresses (alias devices) are assigned to a logical device (base device). This enables to direct several I/O requests to the same volume in parallel. Cache-hits are served simultaneously in the disk storage system, while a cache-miss is operated by physical I/O in parallel.

I/O times are substantially enhanced, because it is possible to eliminate partially or in total the wait times before the volume, that cause increasing software service time, particularly at higher volume load. For TP operation, mainly with high read-hit rates I/O times are reduced by more than 50%. This applies also for high device load. In order to enhance I/O times, in general a third alias is not necessary.

The maximum I/O rates are considerably enhanced, too. With a single alias, the maximum I/O rate can already increase to the 1,8-fold for TP and batch operation. With two alias devices, the maximum throughput increases to the 2 – 2.5-fold. With still more alias devices, a further enhancement is possible at high read-hit rates. The necessity to define very small and hence very many volumes can alleviate.

Note:

The PAV function, introduced with BS2000/OSD-BC V5.0 for Symmetrix connected to the type S channel, is a Symmetrix function that is supported by BS2000, i.e. the appropriate settings (base/alias devices, etc.) must be made at the Symmetrix controller by the service engineer.

In contrast, PAV on the FC channel is a pure software solution that can be put into operation without interventions at the Symmetrix resp.

ETERNUS DX controller.

### Dynamic PAV

Static PAV requires predictive planning of the future utilization of device capacity. In advance one or several alias devices must be assigned to the devices where heavy load is assumed.

In operation of Dynamic PAV (DPAV) for type FC channel, the IORM utility automatically assigns alias devices to devices with heavy load. For this purpose alias devices have to be declared as "DPAV" devices. I/O bottlenecks due to accesses to the same disk by multiple jobs will be alleviated by automatic attachment of alias paths. Similar to static PAV, the alias devices must be included during generation. DPAV makes configuration easier, and fewer devices must be generated.

Recommendation: Operation in PAV/DPAV mode makes always sense, especially with large volumes (volumes > 32 GB).

In order to benefit from the PAV capability a suitable RAID level must be chosen. The best performance values are reached with RAID 1/0.

### RAID 1/0 and Meta Volumes

The RAID level denotes the method used to form fault-tolerant and powerful disk storage systems. In RAID 1/0 (striping + full mirror), two disks are combined in each case to form a RAID 1 ("mirror"), where identical data are stored on both disks respectively. The data is then distributed over many of these disk pairs (striping).

Meta Volumes in the Symmetrix are several disk spaces that are linked together and so form a larger LUN. This can be Raid1/0 LUNs, or several splits on different RAID-1s.

The Symmetrix disk storage systems allow so-called "Meta Volumes" to be set up on disk drives connected via the FC channel. These Meta Volumes are logical volumes which can be striped across up to 96 (Symmetrix 8000) or 128 (Symmetrix DMX) physical disks into areas of equal size (slices) when the disk storage system is installed. As of DMX (Enginuity 5x69+) the size of the slices is fix. For FBA Metas the slice size is 2 cylinders = 1920 blocks à 512 bytes.

This can achieve an increase in throughput, particularly with heavy write loads when the cache cannot accept any more data without first performing a save to disk.

Recommendation: RAID 1/0 (and on Symmetrix thereupon Meta Volumes) should be used if high throughput is required.

### SHC-OSD

Starting with SHC-OSD V4.0, the SHC-OSD functions can be used for Symmetrix systems connected via FC channel.

SHC-OSD requires so-called "gatekeeper devices" in order to operate via Fibre Channel. Gatekeeper devices are devices that are specially configured in Symmetrix to handle the input and output of the host components (SHC-OSD in this case). They should be defined as RAID1 disks with 3 to 10 cylinders.

Starting with SHC-OSD version 5.0 Switched SRDF is supported in Fibre Channel configurations.

In a switched SRDF configuration, the Fibre Channel-type remote-link directors are connected with several remote Symmetrix systems via a switch or a switch network. The advantage is:

- More flexibility and connectivity for the SRDF links.
- Integration of the SRDF Fibre Channel links into the SAN.
- Multiple uses of long-distance links.

The version SHC-OSD V8.0 runs as of BS2000/OSD-BC V6.0 and provides amongst others cascaded time finder/clone and SRDF and some supportive features for virtual provisioning and FAST for Symmetrix disk systems.

Integration of ETERNUS DX SW features with BS2000 Storage Host Component SHC-OSD takes place in two steps. The general availability of SHC-OSD V9.0 has been reached in September 2011. This version supports monitor and information functions, Equivalent Copy (EC) and Remote Equivalent Copy (REC) for ETERNUS DX400, DX400-S2 and DX8000 disk systems.

The following version SHC-OSD 10.0 will support further features for ETERNUS DX disk systems in 2012, e.g. SNAP and Data Mobility configurations.

## ETERNUS CS High End

Starting with V5.0C, BS2000/OSD-BC supports the connection of ETERNUS CS High End systems (formerly CentricStor) to the FC channel of the S servers.

For operation with BS2000, the following ETERNUS CS High End variants are available: ETERNUS CS Virtual Tape Controller (CS50), ETERNUS CS Disk Library Edition and ETERNUS CS Virtual Tape Appliance. A total of 16 (within CS50) to 160 (within CS5000) virtual drives are provided on the host side in the basic models, optionally expandable to 1024 virtual drives. Depending on the model a maximum of 1.500.000 virtual volumes can be defined and managed in ETERNUS CS High End.

### Device type

Volumes in the ETERNUS CS system connected to the type S channel are operated in BS2000 as volume type "TAPE-C4". As the volume type is contained in catalog entries and tape labels, the volumes are also supported as volume type TAPE-C4 via Fibre Channel. This enables virtual volumes in the CentricStor system to be processed both via ESCON and via Fibre Channel.

IOPEN is used to generate C4-type tape devices connected to the type FC channel. As an alternative, the devices can be dynamically defined with the ADD-IO-UNIT command.

### Tape Library

The library is controlled via an external ROBAR server. The library path always runs via LAN independently of the I/O path (ESCON or Fibre Channel).

BS2000 and ROBAR work with the device MN, so the link to the LUN has to be established via the CentricStor configuration for the BS2000 devices (FC and ESCON).

### ETERNUS CS Virtual Tape Controller

The ETERNUS CS Virtual Tape Controller (CS50) is a tape automation solution that is specially tailored in terms of price/performance ratio to BS2000 customers with performance requirements closer to the lower end of the performance spectrum. The CS50 provides access to the latest tape technology for BS2000/OSD Business Servers.

Because of its compatibility with the ETERNUS CS Virtual Tape Appliances, the CS50 can also be deployed as a backup system for disaster recovery or for exchanging data media in ETERNUS CS format.

With the Virtual Tape Controller, customers' application software is still able to write and read (virtual) TAPE-C4 data media, but at the same time can always use current drives as the real hardware.

A total of 16 virtual drives (optionally expandable to 32 virtual drives) are provided on the host side, and 20.000 virtual volumes can be managed.

Note: ETERNUS CS50 does not have an ESCON board! So contrarily to the former CentricStor VTC, ETERNUS CS50 cannot be used for ESCON -> FC migration (Data backup on the old server via ESCON and then change to the new FC server).

## Scalar Tape Library Systems with LTO technology

As an alternative or in coexistence to connection via ETERNUS CS/CentricStor, LTO devices in real tape libraries can be attached directly to BS2000/OSD servers. Currently, FTS offers models from the Quantum Scalar 10K, i2000/i6000 and i500 series of datacenter tape libraries with different storage capacities for BS2000/OSD servers:

Scalar 10K: tape library system with storage capacity of 700 to 13,884 cartridges

Scalar i2000/i6000: tape library system with storage capacity of 100 to 5,322 cartridges

Scalar i500: tape library system with storage capacity of 41 to 409 cartridges.

The ROBAR archiving software is used for communication between BS2000 system(s) and the tape library system. ROBAR manages the cartridges of the tape library system (partition) assigned to it by the configuration and converts the device and cartridge requests by system and user processes into tape library system control commands.

In contrast to ETERNUS CS operation, with this solution the customer receives the original tape format generated in BS2000 and can use the tapes e.g. directly for data exchange.

### Note on Scalar i6000

The Scalar i2000 basic systems are no more orderable as new since May 2010. The Scalar i6000 is intended to replace and extend the Scalar i2000 as part of Quantum's Scalar series of tape automation products. Currently the Scalar i6000 is operable with BS2000 in Scalar i2000-compatible mode. The explicit BS2000 support for Scalar i6000 is in preparation.

The following table gives an overview of the supported HW-SW-configurations with Scalar library systems:

Library System	Drive	OS Support	Archive Software	Release Date
		as of BS2000/OSD-BC	as of ROBAR	
Scalar 10K	LTO-2	V6.0A	V5.0	January 2005
	LTO-3	V6.0B	V6.0	January 2007
	LTO-4	V8.0	V6.0	May 2009
	LTO-5	V8.0	V6.0	September 2011
Scalar i2k/i6k	LTO-2	V6.0A	V5.0	January 2005
	LTO-3	V6.0B	V6.0	January 2007
	LTO-4	V8.0	V6.0	May 2009
	LTO-5	V8.0	V6.0	August 2011
Scalar i500	LTO-3	V6.0B	V6.0	January 2007
	LTO-4	V8.0	V6.0	May 2009
	LTO-5	V8.0	V6.0	July 2011

Notes: Only the IBM LTO drives are released for operation with BS2000/OSD.  
Presumably until 1<sup>st</sup> half of 2012, Scalar i6k with BS2000/OSD will require the i2k compatibility mode.

If the high-performance LTO-3, LTO-4 or LTO-5 drives are to be connected directly to BS2000 hosts (directly means without ETERNUS CS), a well-balanced configuration is supposed, i.e. also fast disk peripherals are required, the disks must be connected via Fibre Channel. PAV (Parallel Access Volume) or DPAV must be used for disk access on S servers.

The maximum data rate of LTO drives is 140 MB/sec (LTO-5, uncompressed) or 120 MB/sec (LTO-4, uncompressed), compared to 80 MB/sec with LTO-3. To adequately service the high data rates of LTO-3, LTO-4 and LTO-5 devices, it is necessary to use the newer versions of the BS2000 backup products, which provide equivalent performance on the disk side through parallelization of disk accesses (HSMS/ARCHIVE as of V8.0B, FDDRL as of V16.0).

If no optimum disk configuration is available, the LTO devices' standard compression function can be switched off with the I/O resource manager IORM's TCOM tape compression function, in order to decrease the minimum data rate that is required for the LTO tapes streaming function.

### LTO-4 tape encryption with MAREN V12.0

The LTO-4 and LTO-5 drives can be equipped with a 'tape encryption' hardware feature. With tape encryption enabled, tape access performance is reduced only by less than 1% in terms of data rate. This affords a highly effective means of implementing data protection at tape level, enabling tape contents to be protected against unauthorized reading, especially when in transit, when stored externally (e.g. in fireproof vaults) and when on loan.

Support for tape encryption is provided as an extension to the MAREN product for magnetic tape management in BS2000/OSD in MAREN V12.0. MAREN handles both the key management function and control of encryption and decryption. The encryption is performed in accordance with the AES standard using a symmetric 256-bit key.

BS2000 control of LTO encryption is only available when the LTO devices are connected directly (i.e. without ETERNUS CS) in conjunction with a library attached to a BS2000 host.

## BS2000 LAN Connection with HNC-IV and HNC-V

### HNC IV

The High-speed Net Connect HNC-IV offers a high performance network connection for BS2000/OSD systems. HNC-IV is built modularly based on a high performance PRIMERGY™ system. On the server site, besides the connection via type S channel, connection via Fibre Channel is offered for the first time. On the LAN site, Fast Ethernet™ and Gigabit Ethernet™ connections are supported. As of software release V1.0A06 from November 2007, the direct connection of the HNC-IV to the BS2000/OSD server without FC switch is possible.

With the Fibre Channel connection, the high throughput rate of the Gigabit LAN is supported on the channel site in an adequate way. (See section „Performance“ for details)

The Fibre Channel support was realized in openNet Server as of version V3.1 (with Rep corrections from correction package 01/2006).

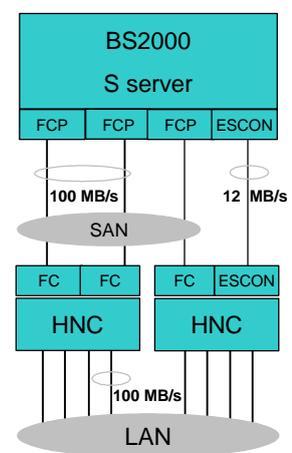
In the openNet Server version V3.2 the data throughput via type FC channel was increased by means of tuning measures (use of max. 128 KB frame buffer) compared with openNet Server V3.1. So operation of openNet Server V3.2 at minimum is recommended.

With BS2000/OSD-BC V8.0 the version openNet Server V3.3 is being offered, this version runs as of BS2000/OSD-BC V6.0. With this version data throughput was increased once more (see section "Performance").

### HNC-V

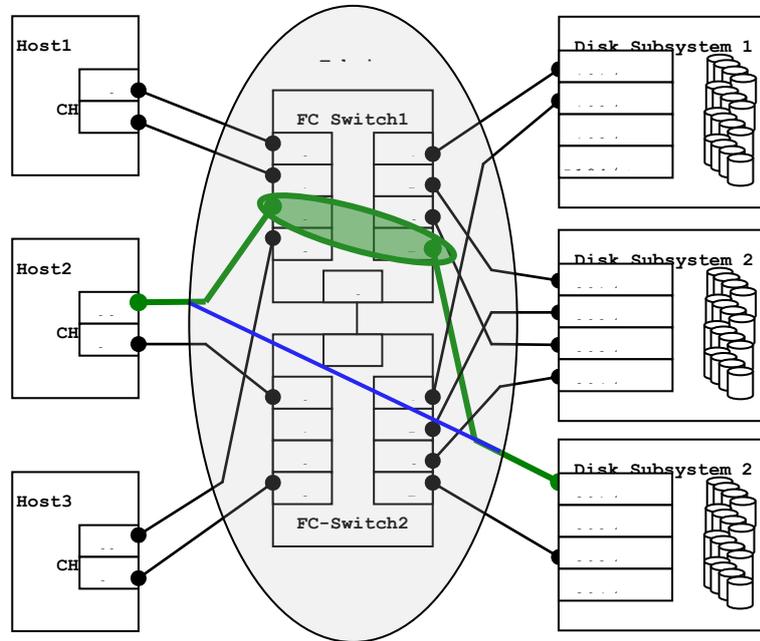
High-speed Net Connect HNC-V offers Fibre Channel connection only.

With openNet Server version V3.4 (General release in November 2010), HNC V supports line aggregation and checksum offload. This offers up to two times larger performance than in former generations, depending on the customer's configuration.



## Diagnosis of Fibre Channel configuration problems

The complexity of the cabling and generation of the components has increased due to the introduction of Fibre Channel/SAN in the BS2000 environment. With SAN connection technology, only a limited view of the actual peripherals is possible using the existing control and monitoring functions. Consequently it is difficult to trace the causes of errors during online operation or when devices are attached.



The SANCHECK utility is designed to support the detection of generation errors and the location of error states in the SAN. The following functions are provided:

### SHOW-SAN-PATH

This command allows to search and to show the path via the SAN switches for a predefined selection of the hardware configurations' source and target units. Dependent of the given operands, the paths are checked for all the systems' generated connections, or all generated connections to a given hardware unit, or only a connection between two given units.

### SHOW-SAN-CONFIGURATION

This command shows information for the required SAN components.

The SAN configuration data is determined using POSIX-based SNMP interfaces. The "getmany" SNMP functions used by SAN CHECK are provided within the SNMP-LIGHT BS2000/OSD-BC component as well as within the SBA-BS2 product (SNMP-Basic-Agent BS2000). BS2000/OSD-BC V8.0 and V7.0B provide a new SANCHECK version V2.0, which no more needs SNMP-LIGHT or SBA-BS2 in order to discover the SAN configuration data.

After each modification of the configuration definition and after changes in cabling or zoning settings, SANCHECK should be used for a comparison of the configuration definition and the actual cabling and zoning settings. By doing this configuration problems can be detected and eliminated in time.

SANCHECK supports Brocade and McData switches. CISCO switches can be made available for connection to BS2000 on special request, with the restriction that SANCHECK is not supported.

SANCHECK was implemented in BS2000/OSD-BC V7.0 as an unbundled subsystem and was released for BS2000/OSD-BC V5.0C or higher in May 2007.

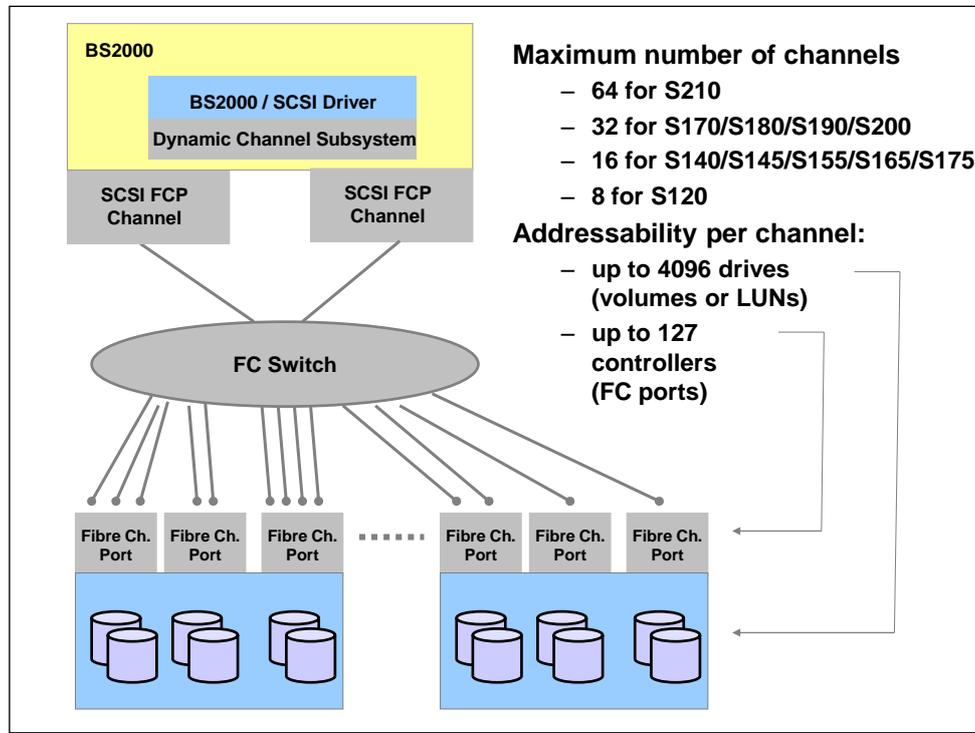
The SANCHECK description is part of the BS2000/OSD-BC V7.0 and V8.0 utility manual resp. was published as a readme file in addition to the BS2000/OSD-BC V6.0 and V5.0 manuals.

In addition, a description paper "Fibre Channel Error Detection for S Series BS2000/OSD Business Servers" is available. With some examples of configuration problems this document helps in detecting and eliminating the reason of such problems. The description paper is available in the internet:

[Fibre Channel Error Detection for S Series BS2000/OSD Business Servers](#)

## Supported configurations

Up to 64 FC channels (on S210 servers) can be operated on one S server, depending on model. Up to 127 controllers (FC ports) and max. 4096 devices can be connected to one FC channel. A maximum of 256 devices is possible per controller (FC port).



The FC switch must operate at 1 Gbit on the host side. Appropriate FC boards must be installed in the peripheral devices (see the summary of the FC configuration data at the end of the document).

Tape devices and FC disks as well as tape devices and HNC may not be configured on the same channel of the S server.

As of software state V1.0A06 released in November 2007, the HNC can be used simultaneously with further HNC or disks connected on the same FC channel of the S server. Disk system and HNC may not be configured in the same zone.

The type of zoning is transparent to BS2000: both node and port zoning can be used.

## Recommendations for SAN configuration settings

It is recommended to fix all SAN configuration settings, to leave out automatism (auto negotiation) and to configure exactly those connection properties needed in operation. These are especially fix FC speed settings and fix FC topology settings. An individual zone to the channel should be setup for every controller.

This leads to higher operation stability and better diagnosis possibilities in case of errors.

## Configurations with many BS2000 volumes

Only 256 LUNs - and hence only 256 BS2000 volumes - are permitted on one channel path (connection from channel to FC port, identified by a WWPN (World-Wide Port Number)) of the storage system (ETERNUS DX or Symmetrix). More devices can be addressed by an appropriate SAN configuration and by setting up address offsets for the FC ports in the Symmetrix: More than 256 LUNs connected to the same FC port should be generated so that no more than 256 LUNs are combined into one logical controller at a time. Only one logical controller is permitted per channel path, so the same connections of the individual logical controllers must be assigned to different channels in each case. The 2-byte LUN for a device is composed of the LOGICAL-ADDRESS for the controller (1<sup>st</sup> byte of the LUN) and the DEVICE-ADDRESS for the device (2<sup>nd</sup> byte of the LUN).

Technically, 2048 devices (LUNs) can be attached to one FC port of the Symmetrix (4096 devices as of DMX-3). For comparison: No more than 1024 devices can be connected to one ESCON port.

Consequently, when migrating from ESCON to FC on Symmetrix systems with a large number of BS2000 volumes, a corresponding number of FC channels must be provided in the S server and/or FC ports on the Symmetrix.

Recommendations:

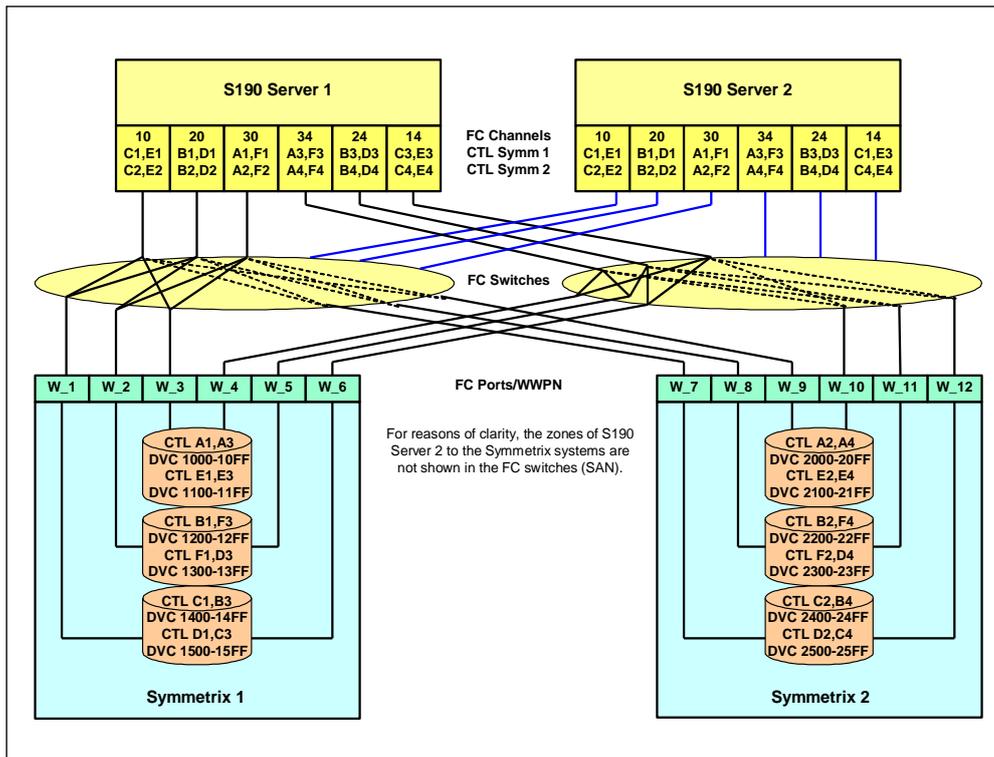
BS2000/OSD operation of the ETERNUS DX systems requires the so-called Linux/NR1000V Mode (Extended Address), where 512 LUNs / Port are supported. These should be generated so that a maximum of 256 LUNs are combined into one logical controller (Affinity Group) at a time. The ETERNUS DX disk system ports which are used for connections to BS2000/OSD business servers can't be used for connections to other servers with different operating systems.

Recommendations:

256 – 1024 LUNs per FC port on the Symmetrix

Number of FC channels on S servers: 1/2 to 1/4 of ESCON

The following diagram shows a sample configuration for a 2 x S190 HA cluster with support for 2 x 1536 devices on 2 x Symmetrix:



The following IO generation statements are associated with the depicted sample configuration:

**BS2000 IOGEN channels**

```

CHN 10, IBF, MODE=FCP
CHN 14, IBF, MODE=FCP
CHN 20, IBF, MODE=FCP
CHN 24, IBF, MODE=FCP
CHN 30, IBF, MODE=FCP
CHN 34, IBF, MODE=FCP
    
```

**BS2000 IOGEN for Symmetrix 1**

```

CTL A1, BLM, A, (30, 0, W_3)
CTL E1, BLM, A, (10, 0, W_3)
CTL A3, BLM, A, (34, 0, W_4)
CTL E3, BLM, A, (14, 0, W_4)

DVC 1000, A5, A, 0000, (A1), (A3), MULT=256
DVC 1100, A5, A, 0100, (E1), (E3), MULT=256

CTL B1, BLM, A, (20, 0, W_2)
CTL F1, BLM, A, (30, 0, W_2)
CTL F3, BLM, A, (34, 0, W_5)
CTL D3, BLM, A, (24, 0, W_5)

DVC 1200, A5, A, 0200, (B1), (F3), MULT=256
DVC 1300, A5, A, 0300, (F1), (D3), MULT=256

CTL C1, BLM, A, (10, 0, W_1)
CTL D1, BLM, A, (20, 0, W_1)
CTL B3, BLM, A, (24, 0, W_6)
CTL C3, BLM, A, (14, 0, W_6)

DVC 1400, A5, A, 0400, (C1), (B3), MULT=256
DVC 1500, A5, A, 0500, (D1), (C3), MULT=256
    
```

**BS2000 IOGEN for Symmetrix 2**

```

CTL A2, BLM, A, (30, 0, W_9)
CTL E2, BLM, A, (10, 0, W_9)
CTL A4, BLM, A, (34, 0, W_10)
CTL E4, BLM, A, (14, 0, W_10)

DVC 2000, A5, A, 0000, (A2), (A4), MULT=256
DVC 2100, A5, A, 0100, (E2), (E4), MULT=256

CTL B2, BLM, A, (20, 0, W_8)
CTL F2, BLM, A, (30, 0, W_8)
CTL F4, BLM, A, (34, 0, W_11)
CTL D4, BLM, A, (24, 0, W_11)

DVC 2200, A5, A, 0200, (B2), (F4), MULT=256
DVC 2300, A5, A, 0300, (F2), (D4), MULT=256

CTL C2, BLM, A, (10, 0, W_7)
CTL D2, BLM, A, (20, 0, W_7)
CTL B4, BLM, A, (24, 0, W_12)
CTL C4, BLM, A, (14, 0, W_12)

DVC 2400, A5, A, 0400, (C2), (B4), MULT=256
DVC 2500, A5, A, 0500, (D2), (C4), MULT=256
    
```

With two-path access, the number of volumes actually available is reduced by half; an additional device address is used per SRDF and BCV volume as well as per PAV alias device.

To reduce the requirement for FC channels and/or FC ports it is possible to reduce the number of BS2000 volumes and increase their capacity. Technically, one way of doing this in the Symmetrix is to use meta volumes, preserving high-speed disk access through striping. However, larger BS2000 volumes may mean additional overhead for customers in order to convert their pubset policy.

Meta Volumes cannot be set up on the ESCON channel, i.e. the transition to meta volumes can only be made during or after the migration to an FC connection.

Also with ETERNUS DX the logical volume size should not be „too small“. Recommendation: Between 25 GB and 100 GB.

## Disk sharing / switching scenarios

### Sharing between S servers

Shared pubset operation between two S systems with FC channel is supported.

Symmetrix systems:

The Symmetrix hardware reserve/release functionality is used to enable disk sharing between systems with FC channels.

If one system is unable to release the hardware reservation (due to an error), the disk has to be released from within a different system.

This unconditional reservation release is reported by the Symmetrix across all FC ports via 'unit attention'. However, the Symmetrix does not report a reservation release caused via FC across the ESCON ports.

Consequently, sharing between S server/FC and S server/ESCON is not possible.

ETERNUS DX systems:

In order to enable disk sharing between systems, the hardware reserve/release functionality was made available for ETERNUS DX with firmware version V20L50. This firmware version was generally released on August 1th, 2010.

### S server – SX / SQ server sharing via FC channel

Symmetrix disk subsystems connected to the FC channel of S servers feature the FBA format with device type D3435.

With OSD/XC V1.1 (with the BS2000/OSD-BC V5.0C correction version in conjunction with X2000 V2.5), the D3435 format was also introduced on the FC channel on the SX servers. This format enables shared pubset operation of a disk between S servers and SX servers via FC channel.

The D3435 format enables as well shared pubset operation of a disk between S servers and SQ servers via FC channel.

The support of ETERNUS DX disks with D3435 format on the SQ servers' FC channel is planned via a new X2000 version at the beginning of 2011. Then the shared pubset operation of an ETERNUS DX disk between S servers and SQ servers with type FC channel will be possible, too.

SPD operation is not supported for FC on S and SX / SQ servers.

### Switching between S servers with FC channel and any BS2000/OSD servers with type S channel

An FBA volume can be connected to BS2000 hosts either via ESCON or via Fibre Channel (FC).

Such a configuration is useful, for example, for a migration from ESCON to FC connection technology. Another usage scenario is the connection of a Symmetrix system to two BS2000 hosts, one of which has an FC connection, while the other is not "FC-capable". (Example: In disaster recovery scenarios, a BS2000/OSD server with type S channel connection is intended to act as a backup system for the S server with FC connection.)

In this configuration it is possible to access a volume first via ESCON and subsequently via FC (or vice versa) (switching operation). Whereas this alternating access to a Symmetrix volume via an ESCON and an FC connection is possible and permitted, contending (shared) access is categorically not permitted and not possible.

An EMC RPQ is required for use in switching mode operation.

## Configurations with ETERNUS CS High End

The logical devices for S servers should be configured in the ETERNUS CS system with connection type FC-SCSI and the IBM 3590E emulation. For S servers, a maximum of 128 logical devices per ICP may be generated (as of CS V4.0). The ETERNUS CS connection to S servers is only possible using an FC switch.

Starting with CentricStor software version V3.0, the so-called head-first Y and Y configuration or the combination as a so-called X configuration is released: several ICP ports can be assigned a shared port (FC channel) of an S server and several S servers can share the same ICP port. The separate LUNs/tape devices are assigned exclusively to one S server with /ATTACH-DEVICE in BS2000. When a device is attached with ATTACH-DEVICE, executing a reserve I/O prevents other systems from working simultaneously with the same device. When the device is detached with DETACH-DEVICE, the reservation is released (release I/O).

Operation of several ICP ports on the same BS2000 FC server port might only make sense for redundancy reasons; efficient loading of the two ICPs is not possible with one FC server port.

Up to and including CentricStor V3.1, the shared use of an ICP port and by that of all logical drives in CentricStor on this ICP port by S servers and SX / SQ servers or by S servers and Open System hosts are not allowed. On the FC switch no other zone with this ICP port - also if the zone is not in use - may be declared by another host. These restrictions are removed by the LUN masking/LUN mapping implemented in ETERNUS CS as of V4.0. ETERNUS CS tape devices and FC disks may not be configured on the same channel of the S server.

## Configurations with Scalar Library Systems

### General notes

A drive may be used by several servers of the same type (only S servers or only SX servers or only SQ servers). Then the simultaneous use on several servers is prohibited by the same reservation mechanism.

Only the Virtual Tape Appliance ETERNUS CS allows the shared use of (physical) drives by BS2000/OSD servers of different types (S servers, SX servers, SQ servers) and Open System servers.

A 2-path connection of LTO devices on S servers is only possible within Scalar i2000/i6000 via IO-Blade (as failover).

All other connections are released only in 1-path form. (This applies for LTO within Scalar 10K, i500 and also for ETERNUS CS).

Only between S server and FC switch, 2 paths are possible for Scalar 10K and Scalar i500 also, in order to protect against FC board failure and switch port failure.

Only the IBM drives are released within the Scalar libraries for direct operation with BS2000/OSD without ETERNUS CS.

### Scalar 10K

Control of the Scalar 10K library system is performed via the ABBA-1 interface. Thus the Scalar 10K was already supported by ROBAR as of version V4.0. The current ROBAR version is V6.0.

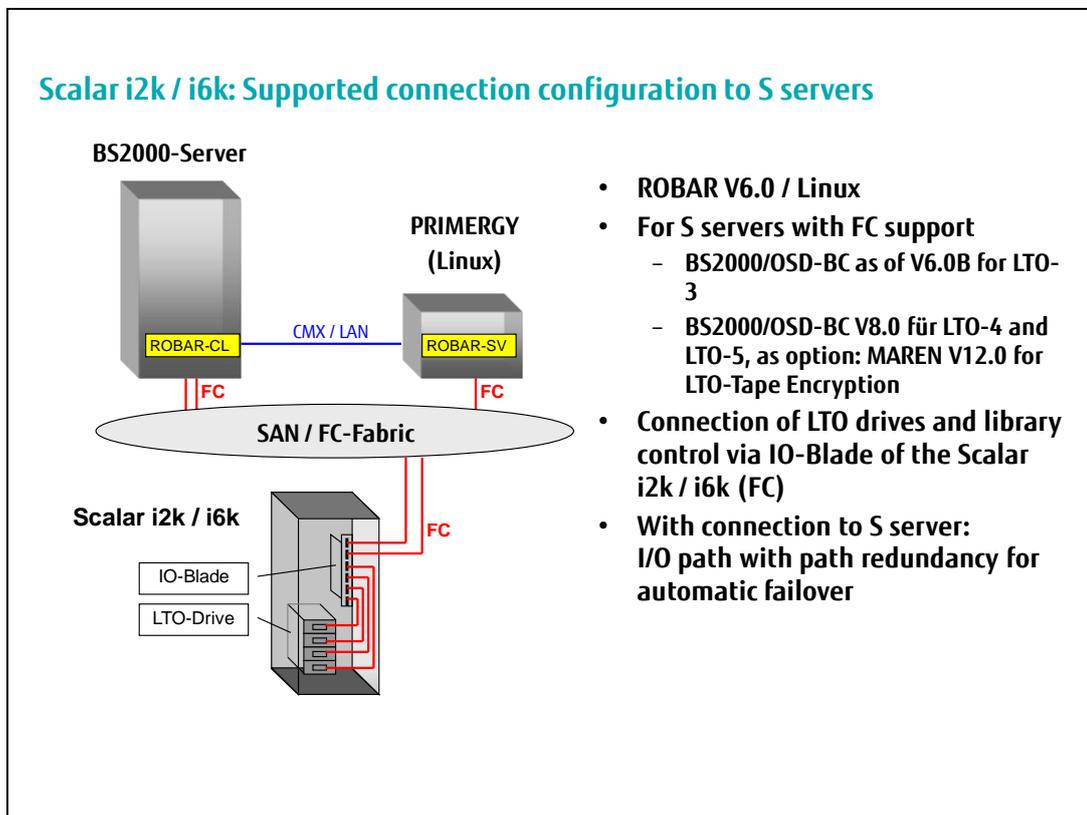
To support LTO-2 drives on the S servers' type FC channel, BS2000/OSD-BC as of V6.0 is required.

LTO-3 with Scalar 10K requires BS2000/OSD-BC V6.0B and ROBAR V6.0.

LTO-4 or LTO-5 with Scalar 10K requires BS2000/OSD-BC V8.0 and ROBAR V6.0.

### Scalar i2000/i6000

The following figure shows the supported configuration of BS2000 S server, ROBAR computer and Scalar i2000/i6000 tape library system with LTO-3, LTO-4 or LTO-5 drives:



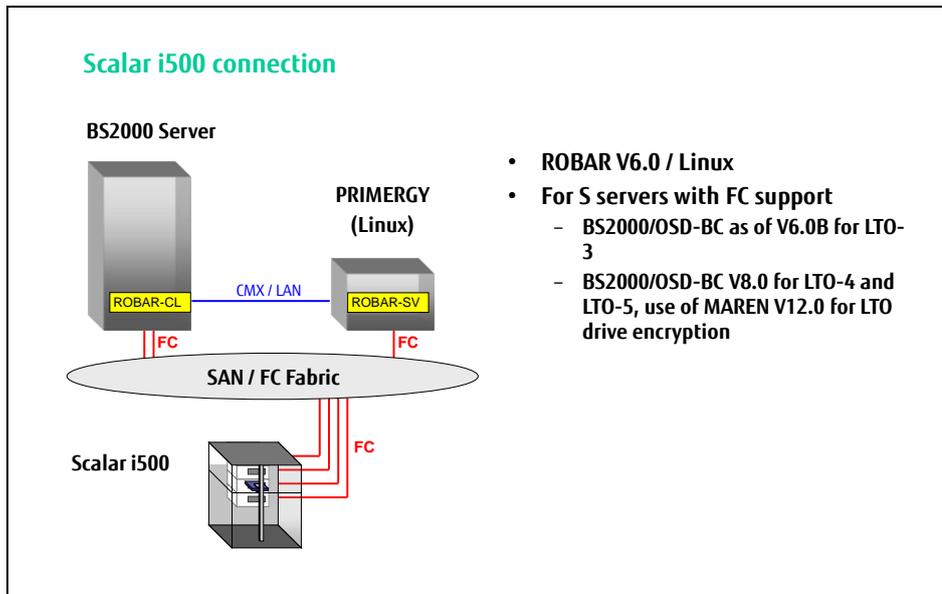
In order for the Scalar i2000 system to be used by different server platforms, the library can be split into several logical partitions using the Q:LSC2K-APAR-001A partitioning license option.

Thus, drives and slots are separated and allow uninterrupted operation in heterogeneous system environments. Only the physical robotics is shared. On a logical level, every partition addresses its drives via its own independent SCSI robot control. LTO-3-, LTO-4- and LTO-5 drives must be operated in separate partitions respectively.

These statements apply accordingly to Scalar i6000 library systems operating in Scalar i2000 compatibility mode.

**Scalar i500**

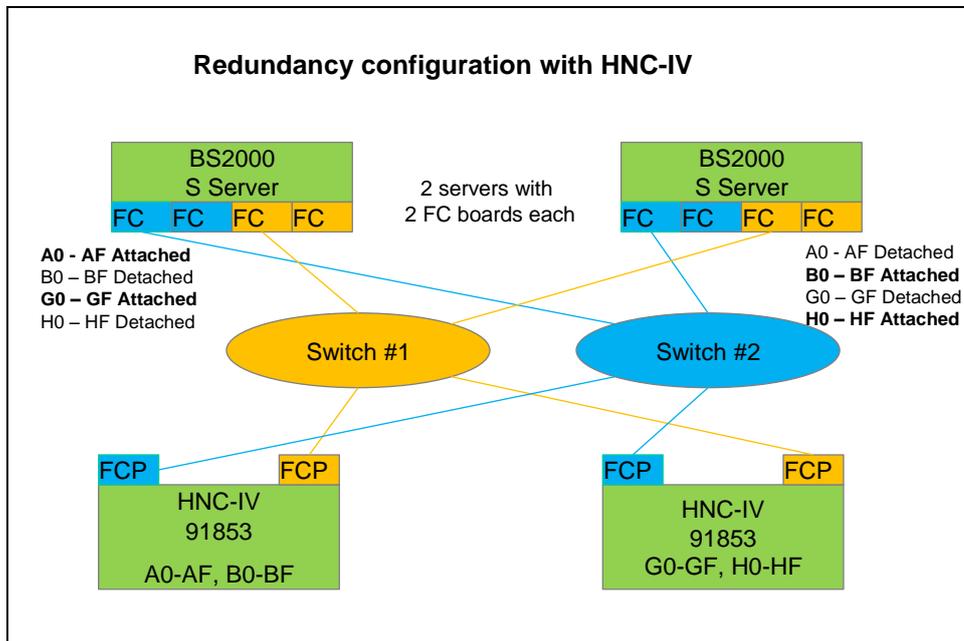
The following figure shows the supported configuration of BS2000 S server, ROBAR computer and Scalar i500 tape library system with LTO-3, LTO-4 or LTO-5 drives:



LTO-3, LTO-4 and LTO-5 drives must be operated in separate partitions respectively. Connection of a Scalar i500 tape library system to BS2000 servers is only possible without IO blade.

**Configurations with HNC-IV and HNC V**

On S servers with type FC channel the HNC is connected either via a Fibre Channel switch or directly to the server's FC channel (without switch). Similarly to CentricStor the FC addresses of an HNC can be generated on two S servers by redundancy reasons (so called Y configuration). By means of zoning it must be ensured that the individual HNC devices are always attached only to a single server (In the figure A0-AF, G0-GF to the server on the left hand side and H0-HF, B0-BF to the server on the right hand side).



## Performance

Using type FC channels achieves significant improvements in performance compared with type S channels. Measurements of type S (with Symmetrix 8530, S170) and type FC (with DMX-3 and V-MAX, S190) are published in the BS2000/OSD-BC V8.0 Performance Handbook.

Main results:

The main improvement over type S brought about by the faster type FC channel is in the transfer time, i.e. the relative gain is greatest with long blocks or high hit rates.

The performance limits of the type FC channel are nearly approached.

One type FC channel can replace about 4 type S channels.

The use of FC channels is to be recommended without restriction from the performance viewpoint.

### Performance measurements with ETERNUS DX8400

In July 2010, performance measurements were performed with the disk storage system ETERNUS DX8400, connected on an S server S200 under BS2000/OSD-BC V8.0. The results are the following:

#### Maximum throughput via one resp. four channels with disk IOs

Over one channel/four channels, the following maximum IO rates (with short blocks of 4 and 8 KB per IO) or the following maximum throughput (given in MB/sec for block sizes of 16 and 32 KB) can be achieved:

Block size (KB)	4	8	16	32
(Random25)	IO/s	IO/s	MB/s	MB/s
1 Type FC channel	7.533	7.666	84	98
4 Type FC channels	27.973	28.478	326	384

#### IO times, enhancements with PAV

With a typical TP load the IO times are about 1-2 msec (Random access with short blocks, mix of 75% Read and 25% Write (Random25), Read-Hit-Rate 80%).

For the RAID10, RAID6 and RAID5 RAID levels with data striping, PAV causes substantial enhancements of the IO rates as well as of the IO times. With an appropriate high load, the enhancements increase with the number of alias devices and concern transaction- and throughput-oriented load cases.

So for ETERNUS DX the same recommendations for dynamic PAV (DPAV) and PAV on S servers apply as for Symmetrix: (D)PAV is to be recommended without restriction; with (D)PAV also very large volumes can be operated with good performance.

Comparing the performance measurement results of ETERNUS DX8400 with those of the EMC disk storage systems from the performance handbook, you obtain:

From a BS2000 viewpoint, the DX8400 and EMC Symmetrix values have the same dimension when connected to an S server. The performance differences are small (mostly less than 10%).

#### Data backup

The higher performance of the type FC channels is demonstrated very impressively by a substantially higher throughput during data backup/recovery with HSMS or FDDRL. In a data backup with HSMS V8.0B (S190 with OSD V7.0, PAV with 1 alias, DMX-3 disk storage system, RAID 1/0, LTO-3 tape devices or CentricStor VTA), significant improvements were produced as a result of using type FC channels (similarly for FDDRL):

Channel	Channel	Throughput (MB/sec)	Throughput (MB/sec)
Disk side	Tape side	SAVE	RESTORE
Type S	Type S	12	12
Type FC	Type S	15	15
Type FC	Type FC (LTO-3)	90	90
Type FC	Type FC (CentricStor VTA)	80	70

Current measurements show that the performance of ETERNUS CS Virtual tape Controller (CS50) is equivalent to the performance of an ETERNUS CS VTA.

#### Network connection

Measurements with openNet Server V3.3 show a very good performance for the HNC-IV with FC connection:

A throughput of ca. 60 resp. 77 MB/s (send/receive) is reached, for Gigabit Ethernet with Jumbo-Frames ca. 65 resp. 82 MB/s.

The maximum transaction rate reaches 85.000 - 91.000 TA/s depending on load.  
Compared to type S channel the throughput is the 4 to 5-fold.

Performance increase with openNet Server 3.4 and HNC V:

- With link aggregation for two FC channels and Jumbo-frames, the gigabit ethernet can be used to full capacity.
- In case of customer loads with long messages, checking and computing of TCP checksums by HNC reliefs the BS2000 CPUs about 10% to 38% with same throughput as before.

For further information please consult the following documents

White Paper

["Efficient Peripheral Operation with BS2000/OSD"](#)

BS2000/OSD-BC V8.0 Performance Handbook (in particular chapters 3, 4 and 5):

<http://manuals.ts.fujitsu.com/file/8996/perform.pdf>

## Summary of FC configuration data

S server	BS2000/OSD S145, S155, S165, S175, S180, S190, S200 and S210 servers
FC channel	D:S145F-FC, D:S165F-FC, D:S175F-FC, D:S180F-FC, D: S200F-FC, D:S210F-FC
Disk storage system Symmetrix	Symmetrix systems type VMAX-1 Symmetrix systems type DMX-4 Symmetrix systems type DMX-3 Symmetrix systems type DMX (DMX800, DMX801, DMX1000, DMX2000, DMX3000) Symmetrix systems type 8000 (8430, 8530, 8230, 8730, 8830)  The disk storage systems must be equipped with Symmetrix FC boards for Fibre Channel connection.
Required Enginuity version for Symmetrix V-Max, DMX-4, DMX-3 and DMX Required Enginuity version for Symmetrix 8xxx	Supported by all Enginuity versions since DMX model resp. VMAX-1 first release  e5568
Disk storage system ETERNUS DX	ETERNUS DX systems type DX8700, DX8400 ETERNUS DX systems type DX440, DX410, DX440 S2, DX410 S2
Required Firmware version for ETERNUS DX	V20L50 V10L13 (for DX400 S2)
ETERNUS CS Disk Library and Virtual Tape Appliance	CS-500-V09/V08, CS-500- V09DL/V08DL, CS-1000- V09/V08, CS-1500- V09/V08, CS-1500- V09DL/V08DL, CS-2000- V09/V08, CS-3000- V09/V08, CS-4000- V09/V08, CS-5000- V09/V08 with software version V5.0 and V4.1
CentricStor VTA	D: CS-xx00-V07 with CentricStor software version V4.0 Formerly: older versions D:CS-x000-V0x with CentricStor software version V3.1 and D:3595-100-LIB, D:3595-100, D:3595-400
CentricStor SBU (Smart Backup Unit)	D:CS-SBU-V07 CentricStor SBU with 38HE system rack, console switch and rack console, with CentricStor software version V4.0 Formerly: older versions D:CS-SBU-V06 CentricStor SBU with CentricStor software version V3.1, and CentricStor SBU complete system with library Scalar i500 resp. Scalar 100, ROBAR hardware/software and MAREN
ETERNUS CS Virtual Tape Controller	CS-50-V08 for rack installation, with CentricStor software version V4.1 A complete package comparable to the former SBU is no more predefined. It can be configured by means of the System Architect.
CentricStor VTC (Virtual Tape Controller)	D:CS-VTC-V07 for rack installation, with CentricStor software version V4.0 Formerly: D:CS-VTC-V06 for rack installation, with CentricStor software version V3.1, and D:ITC-R1 ITC for rack installation
Scalar 10K	D:SC10K-BL7 Scalar 10K base module for 700 LTO cartridges, with D:SC10K-CIL1/ CIL5 capacity upgrade in increments of 100/500 slots at a time up to an upper limit of 13.884 slots.
LTO-5/LTO-4/LTO-3/LTO-2 drive with FC connection for Quantum Scalar 10K	Q:9-02025-01 Scalar 10K IBM LTO-5 Tape Drive Module, 4Gb native FC D:SC10K-DU4F IBM LTO 4 drive with connection via FC native for Scalar 10K D:SC10K-DU3FN IBM LTO 3 drive with connection via FC native for Scalar 10K Formerly D:SC10K-DU2FN LTO 2 drive with connection via FC native for Scalar 10K

Scalar i2000	D:SCI2000-Lx Scalar i2000 with 100 to 3,000 slots, expandable to max. 3,492 slots
Scalar i6000 (operation in Scalar i2000-compatibility mode)	Q:LSC6K-BL00-0xxA Scalar i6000 with 100 to 5.000 slots, expandable to max. 5.322 slots
LTO-5/LTO-4/LTO-3/LTO-2 drive with FC connection for Scalar i2000 and Scalar i6000	<p><b>IBM LTO-5</b> <sup>1</sup></p> <p>Q:LSC6K-UTDT-L5BA: Scalar i6000 IBM LTO-5 Drive, 4Gb Storage Networking IBM LTO-4</p> <p>D:SCI2K-FTDT-L4BE drive LTO-Ultrium 4 networking for SCI2000 or D:SCI2K-FTDG-L4BE drive LTO-Ultrium 4 FC native with Q: LSC2K-AFCC-001A I/O blade for Scalar i2000/i6000 (includes FC ports) IBM LTO-3</p> <p>D:SCI2K-FTDT-L3BA drive LTO-Ultrium 3 networking for SCI2000 or D:SCI2K-FTDG-L3BA drive LTO-Ultrium 3 FC native with Q: LSC2K-AFCC-001A I/O blade for Scalar i2000/i6000 (includes FC ports) Formerly for Scalar i2000</p> <p>D:SCI2000-DU3N drive LTO-Ultrium 3 networking for SCI2000 or D:SCI2000-DU3F4 drive LTO-Ultrium 3 FC native with D:SCI2000-IOB I/O blade for Scalar i2000 (includes FC ports) Formerly for Scalar i2000</p> <p>D:SCI2000-DU2N drive LTO-Ultrium 2 networking for SCI2000 or D:SCI2000-DU2F drive LTO-Ultrium 2 FC native with D:SCI2000-IOB I/O blade for Scalar i2000 (includes FC ports)</p>
Scalar i500	<p>D:SCI501-CL4G Scalar i500 with one or two LTO-4 Fibre Channel drives , max. 18 drives available; with 41 slots, expandable to max. 409 slots</p> <p>D:SCI500-LxxF Scalar i500 with one or two LTO-3 Fibre Channel drives, max. 18 drives available; with 41 slots, expandable to max. 409 slots</p>
LTO-5/LTO-4-/LTO-3 drive with FC connection for Scalar i500	<p>IBM LTO-5: Q:LSC5H-UTDJ-L5BA: Quantum Scalar i500 IBM LTO-5 FC Drive, 8Gb</p> <p>IBM LTO-4: D:SCI500-DU4F drive LTO-4 FC native for SCI500</p> <p>IBM LTO-3: D:SCI500-DU3F drive LTO-Ultrium 3 FC native for SCI500</p>
HNC-V	D:91854-FLOOR oder D:91854-RACK (2 x type FC, 2 x LAN 10/100/1000), Base models can be extended up to 4 x LAN
HNC-IV	<p>D:91853-FIBER-CHAN (2 x type FC, 2 x LAN 10/100/1000)</p> <p>D:91853-UNIVERSAL (1 x type FC + 1x Typ S, 2 x LAN 10/100/1000)</p> <p>Base models expandable to 4 x LAN</p>

<sup>1)</sup> Only the IBM LTO drives were released for operation with BS2000. When ordering a new Tape Library with LTO-4 drives, you must insert in the SAP remark field the text „order is a BS2 configuration, only IBM drives allowed“.

<p>Fibre Channel Switch</p>	<p>Brocade switch 1Gbit/s and 2, 4 or 8 Gbit/s with 1Gbit compatibility:</p>	
	<p>4 or 8 GB/s switch (current):                      operation only with the 4Gbit/sec SFPs                      (Small Formfactor Pluggable FCSFP-B-MM4G)                      D:FCSW-300L/E (8 Ports)                      D:FCSW-300L/E-UPG16 (Ports 9-16)                      D:FCSW-300L/E-UPG24 (Ports 17-24)                      D:FCSW-5100E/L (24 Ports)                      D:FCSW-5100E/L-UPG32 (Ports 25-32)                      D:FCSW-5100E/L-UPG40 (Ports 33-40)                      D:FCSW-5300E/L (48 Ports)                      D:FCSW-5300E/L-UPG64 (Ports 49-64)                      D:FCSW-5300E/L-UPG80 (Ports 65-80)                      D:FCSW-48K (32 to 384 Ports)                      Brocade Director DCX, DCX-4S</p>	<p>Silkworm 300                      Silkworm 300                      Silkworm 300                      Silkworm 5100                      Silkworm 5100                      Silkworm 5100                      Silkworm 5300                      Silkworm 5300                      Silkworm 5300                      Brocade 48000 Director                      Brocade DCX Backbone</p>
	<p>2 or 4 GB/s switch (already withdrawn):                      D:FCSW-8P2GB01                      D:FCSW-8P2G3250/55                      D:FCSW-08P200EL/EE                      D:FCSWR-08P200EL/EE                      D:FCSW-16P200EL/EE                      D:FCSWR-16P200EL/EE                      D:FCSW-16P2GB01                      D:FCSW-16P2G3850/55                      D:FCSW-32P2G3900                      D:FCSW-32P2GB01                      D:FCSW-32P4116(L)                      D:FCSWR-32P4100E/L                      D:FCSW-32P5000L/E                      D:FCSW-64P2GB01                      D:FCSW-64P4932L/E                      D:FCSW-128P2GB01                      D:FCSW-128P24032</p>	<p>Silkworm 3200                      Silkworm 3250                      Silkworm 200E                      Silkworm 200E                      Silkworm 200E                      Silkworm 200E                      Silkworm 200E                      Silkworm 3800                      Silkworm 3850                      Silkworm 3900                      Silkworm 12000                      Silkworm 4100                      Silkworm 4100                      Silkworm 5000                      Silkworm 12000                      Silkworm 4900                      Silkworm 12000                      Silkworm 24000</p>
	<p>For more FC switches (EMC Connectrix, McDATA) see EMC matrix at the following address:  <a href="http://www.emc.com/products/interoperability/index.htm">http://www.emc.com/products/interoperability/index.htm</a></p>	
<p>Operating system version and software requirements for Symmetrix disk connection</p>	<p>BS2000/OSD-BC V5.0B or higher, or VM2000 V7.0 or higher with BS2000/OSD-BC V5.0B or higher as monitor system and as guest system                      For DMX-3/DMX-4: BS2000/OSD-BC V5.0C or higher, with Rep corrections (of correction package 02/2005) for DMX-3 with Rep corrections (of correction package 02/2007) for DMX-4                      Optional: SHC-OSD V4.0 or higher                      For DMX-3: SHC-OSD as of V5.0A01, for Microcode e5772 SHC-OSD as of V6.1A01                      For DMX-4: SHC-OSD as of V6.0A01, for Microcode e5773 SHC-OSD as of V6.1A02                      For Symmetrix VMAX-1: BS2000/OSD-BC as of V6.0B with Rep corrections for VMAX-1 (Release with correction package 01/2009)                      Optional: SHC-OSD as of V7.0A01</p>	

Operating system version and software requirements for ETERNUS DX disk connection	BS2000/OSD-BC V7.0B or higher, or VM2000 V9.0B or higher with BS2000/OSD-BC V7.0B or higher as monitor system and as guest system with Rep corrections for BS2000/OSD-BC V8.0, V7.0B and VM2000 V9.0B (Release with correction package 02/2010)
Operating system version and software requirements for ETERNUS CS resp. CentricStor connection (valid for CentricStor as of V3.1D)	BS2000/OSD-BC as of V5.0C with Rep corrections (released with correction package 01/2005), or VM2000 as of V7.0 with BS2000/OSD-BC V5.0C as monitor and as guest system ROBAR as of V5.0 MAREN as of V10.0 resp. MAREN V9.0B with optional Rep A0504294
Operating system version and software requirements for Scalar 10K and i2000 operation with LTO-2 or LTO-3	BS2000/OSD-BC as of V6.0A (LTO-2) resp. V6.0B (LTO-3), or VM2000 as of V8.0 with BS2000/OSD-BC as of V6.0A (LTO-2) resp. V6.0B (LTO-3) as monitor system and as guest system LTO-2: ROBAR as of V5.0; LTO-3: ROBAR V6.0 MAREN as of V10.0
Operating system version and software requirements for Scalar i500 operation with LTO-3	BS2000/OSD-BC as of V6.0B, or VM2000 as of V8.0 with BS2000/OSD-BC as of V6.0B as monitor system and as guest system ROBAR V6.0 MAREN as of V10.0
Operating system version and software requirements for Scalar 10K, i2000 and i500 operation with LTO-4 or LTO-5	BS2000/OSD-BC V8.0, resp. VM2000 V9.0 with BS2000/OSD-BC V8.0 as monitor system and as guest system ROBAR V6.0 MAREN V12.0 (for Encryption) or MAREN V11.0 Correction package 1/2011 is required for use of LTO-5.
Operating system version and software requirements for HNC connection	BS2000/OSD-BC as of V5.0C, or VM2000 V7.0 or higher with BS2000/OSD-BC as of V5.0C as monitor system and as guest system openNet Server V3.1 or higher with Rep corrections (Release with correction package 01/2006); recommended: openNet Server as of V3.2 openNet Server V3.4 or higher for use of line aggregation and checksum offloading

**Contact**

FUJITSU Technology Solutions GmbH  
Mies-van-der-Rohe-Straße 8, 80807 Munich, Germany  
E-mail: BS2marketing@ts.fujitsu.com  
Website: <http://ts.fujitsu.com>  
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