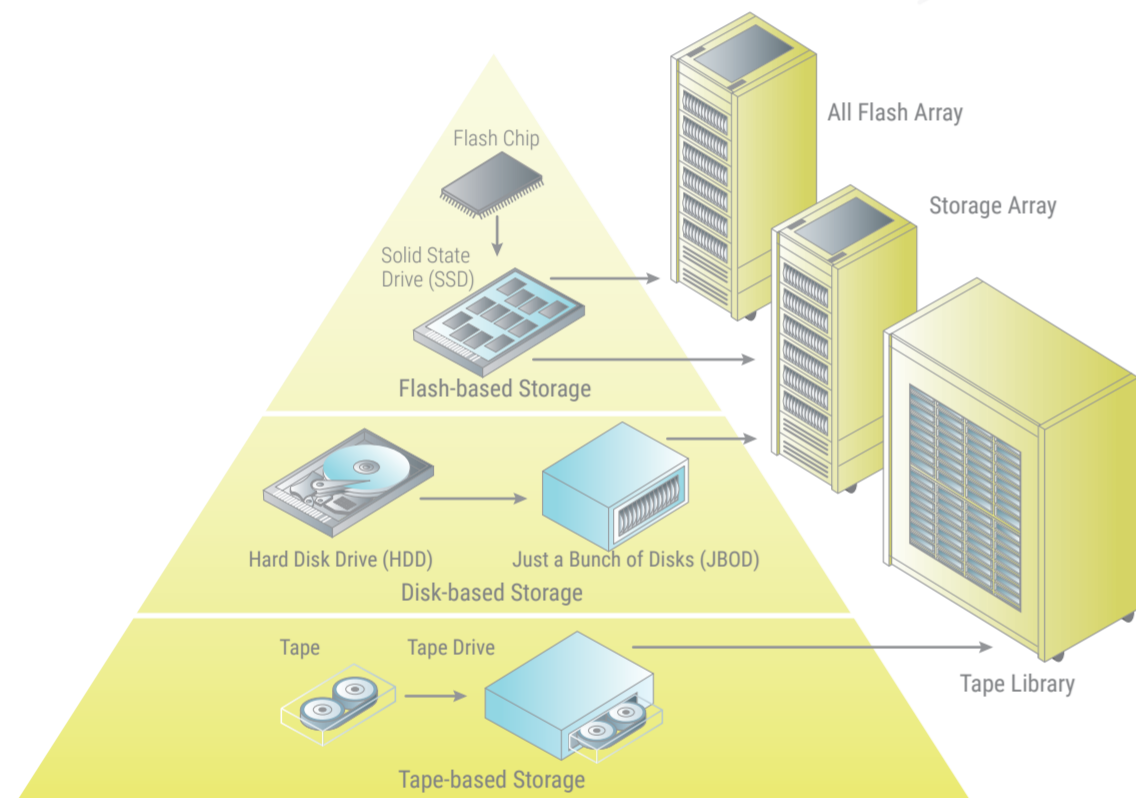


# STORAGE AREA NETWORKS

## MAIN DATA CENTER

Fibre Channel is at the heart of the data center connecting servers to storage, and relied upon for the most strenuous workloads. For example, Fibre Channel is deployed in many high-end applications in financial and governmental institutions where reliability and scalability are paramount. Fibre Channel consistently delivers greater than "five 9s" or 99.999% uptime as measured by vendors and customers in data center deployments worldwide. Fibre Channel storage area networks are often completely redundant to ensure constant service and uncorrupted data without single points of failure.

- Server Racks
- Ethernet Switch and Router Racks
- Fibre Channel
- Patch Panels
- Storage Racks
- Transport Equipment

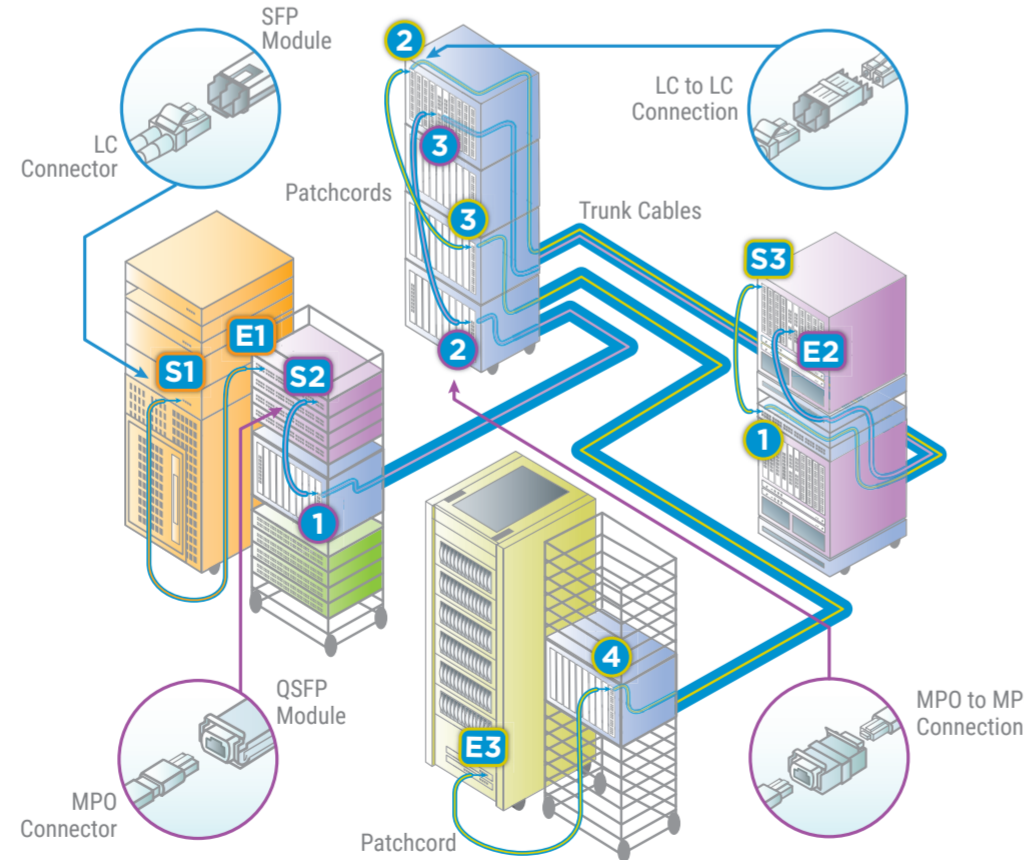


## STORAGE HIERARCHY

The venerable storage triangle shows how flash has traditionally been used for the highest performing applications while hard disk drives are used for mainstream storage and tape for archiving. The rapid growth in capacity and reduction in cost of NAND Flash technology is turning the storage triangle upside down by enabling flash-based archival storage products and NVMe All Flash Arrays. Delivering higher throughput, lower latency and low power, the flash based storage, and in particular NVMe over Fibre Channel is driving the need for high speed Fibre Channel.

## CABLING SYSTEMS

The diagram on the right shows three typical links between servers and storage. Link 1 from a server to an edge switch has no fiber optic connections and is a simple point-to-point link. Link 2 is a 128GFC Inter-Switch Link (ISL) from a QSFP28 to a QSFP28 that is connected with MPO connectors. Link 3 connects switches to storage via two trunk cables and has 4 LC connections with up to 1.5dB of connector loss to support 100 meters.



Link	Start	End	Connections	# of Fibers
1	Server (S1)	Edge Switch (E1)	0	2
2	Edge Switch (S2)	Core Switch (E2)	3	12
3	Core Switch (S3)	Storage Array (E3)	4	2

## SERVER CONNECTIONS

Servers are connected to Fibre Channel networks with host bus adapters (HBAs) or converged network adapters (CNAs). HBAs adapt Peripheral Component Interconnect (PCI) connections to Fibre Channel ports. HBAs and often have multiple ports that are connected to dual fabrics to ensure high availability.

## DISK MIRRORING

To ensure that every transaction is reliably processed, disk arrays are mirrored between data centers. Often spanning thousands of miles, primary disk arrays are mirrored so that the secondary disk array contains the exact same information upon failure of the primary.

## DUAL FABRICS

To ensure application uptime and highly reliable access to data, Fibre Channel fabrics are usually configured with an "air gap" between redundant fabrics. The air gap means that fabric "A" can completely fail and the backup fabric "B" will become the primary so that servers don't lose access to their valuable data.

## MAINFRAMES

Mainframes are still at the heart of most financial transactions because of their proven reliability and scalability. Often considered a different data center within a data center, mainframes have reliability requirements over "five-9s" and FICON (Fibre Channel used in mainframes) connects to storage, tape libraries and printers reliably and securely.

## NVMe OVER FIBRE CHANNEL

All Flash Arrays running NVMe Express are becoming the new norm in data centers. Fibre Channel's NVMe over FC (FC-NVMe) is designed to allow Fibre Channel to ride this new technology wave to new levels of performance. Add in Fibre Channel's well known reliability, and NVMe over FC becomes the new standard for data center SANs.

## DISASTER RECOVERY SITE

This disaster recovery site mirrors data via Fibre Channel to multiple sites and archives data in tape libraries and virtual tape libraries. In the case of a remote site failure, the disaster recovery site goes live and secondary servers are activated to become primary servers. Fibre Channel uses Fibre Channel Internet Protocol (FCIP) and transport (DWDM or long haul) networks to connect multiple data centers around the world to keep data synchronized and highly available. Solutions based on Fibre Channel have proven their effectiveness in ensuring highly reliable data transfers at gigabit/second speeds.