List and explain different FC connectivity with a neat diagram

FC Connectivity

The FC architecture supports three basic interconnectivity options:

1) **Point-To-point,**
2) **Arbitrated Loop (Fc-AL),**
3) **FC Switched Fabric**

Point-to-Point

- **Point-to-point** is the simplest FC configuration — two devices are connected directly to each other, as shown in Fig 2.4.
- This configuration provides a dedicated connection for data transmission between nodes.
- The point-to-point configuration offers limited connectivity, as only two devices can communicate with each other at a given time.
- It cannot be scaled to accommodate a large number of network devices. Standard DAS uses point to- point connectivity.

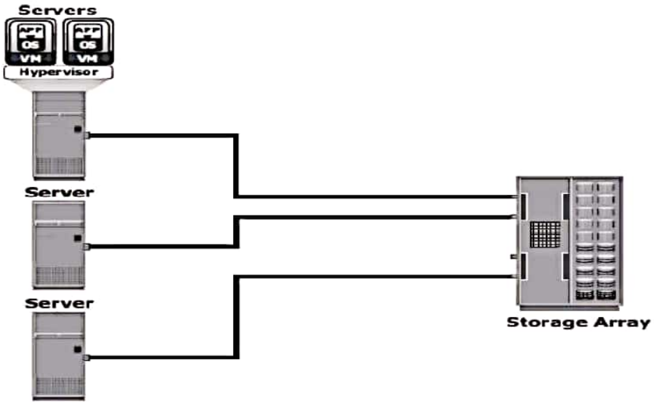


Fig 2.4: Point-to-point connectivity

Fibre Channel Arbitrated Loop

- In the FC-AL configuration, devices are attached to a shared loop, as shown in Fig 2.5.
- FC-AL has the characteristics of a **token ring topology and a physical star topology**.
- In FC-AL, each device contends with other devices to perform I/O operations. Devices on the loop must "arbitrate" to gain control of the loop.
- At any given time, only one device can perform I/O operations on the loop.
- FC-AL implementations may also use hubs whereby the arbitrated loop is physically connected in a star topology.

The FC-AL configuration has the following limitations in terms of scalability:

- FC-AL shares the bandwidth in the loop.
- Only one device can perform I/O operations at a time. Because each device in a loop has to wait for its turn to process an I/O request, the speed of data transmission is low in an FC-AL topology.
- FC-AL uses 8-bit addressing. It can support up to 127 devices on a loop.
- Adding or removing a device results in loop re-initialization, which can cause a momentary pause in loop traffic.

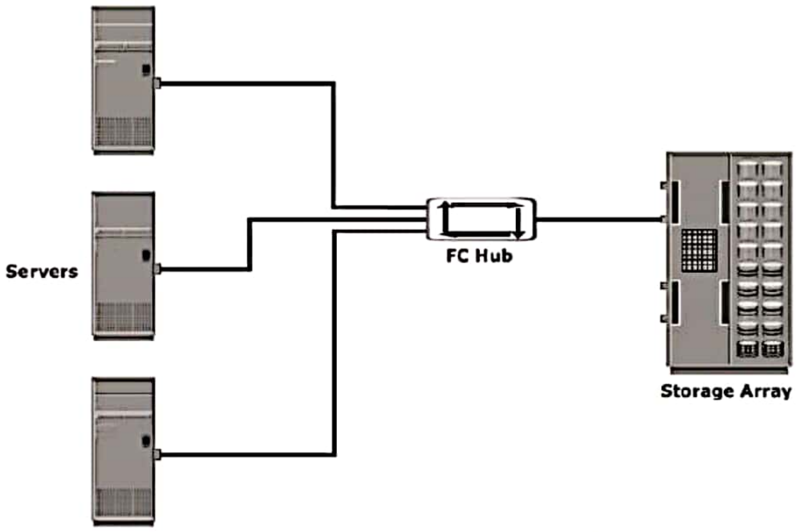


Fig 2.5: Fibre Channel Arbitrated Loop

Fibre Channel Switched Fabric(FC-SW)

- FC-SW provides dedicated data path and scalability.
- The addition and removal of a device doesnot affect the on-going traffic between other devices.
- FC-SW is referred to as **Fabric connect**.
- A Fabric is a logical space in which all nodes communicate with one another in a network. This virtual space can be created with a switch or a network of switches.
- Each switch in a fabric contains a a unique domain identifi er, which is part of the fabric's addressing scheme.
- In a switched fabric, the link between any two switches is called an *Interswitch link* (ISL).
- ISLs enable switches to be connected together to form a single, larger fabric.
- ISLs are used to transfer host-to-storage data and fabric management traffic from one switch to another.
- By using ISLs, a switched fabric can be expanded to connect a large number of nodes.

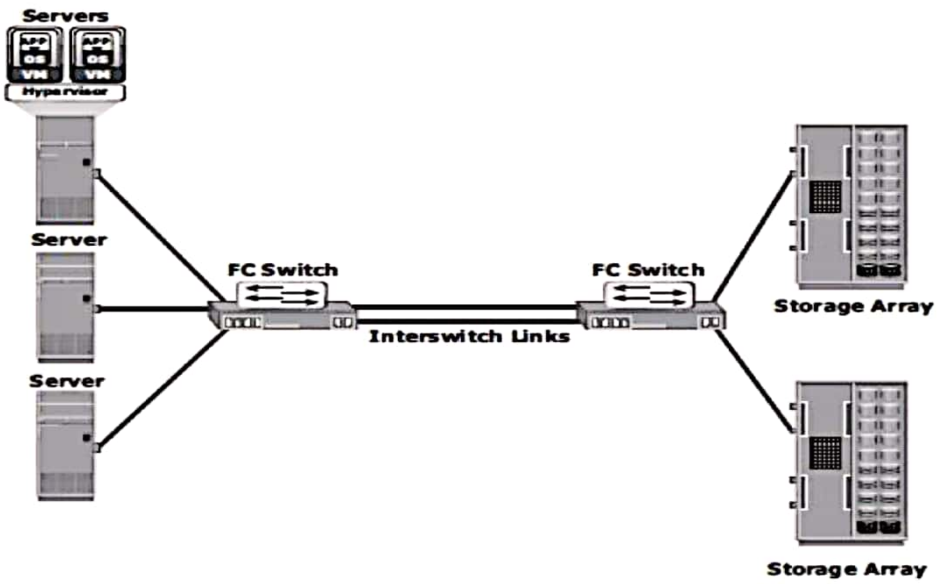


Fig 2.6: Fibre Channel switched Fabric

With neat daigram explain ISCSI implementation

iSCSI

- iSCSI is an IP based protocol that establishes and manages connections between host and storage over IP, as shown in Fig 2.21.
- iSCSI encapsulates SCSI commands and data into an IP packet and transports them using TCP/IP.
- iSCSI is widely adopted for connecting servers to storage because it is relatively inexpensive and easy to implement, especially in environments in which an FC SAN does not exist.

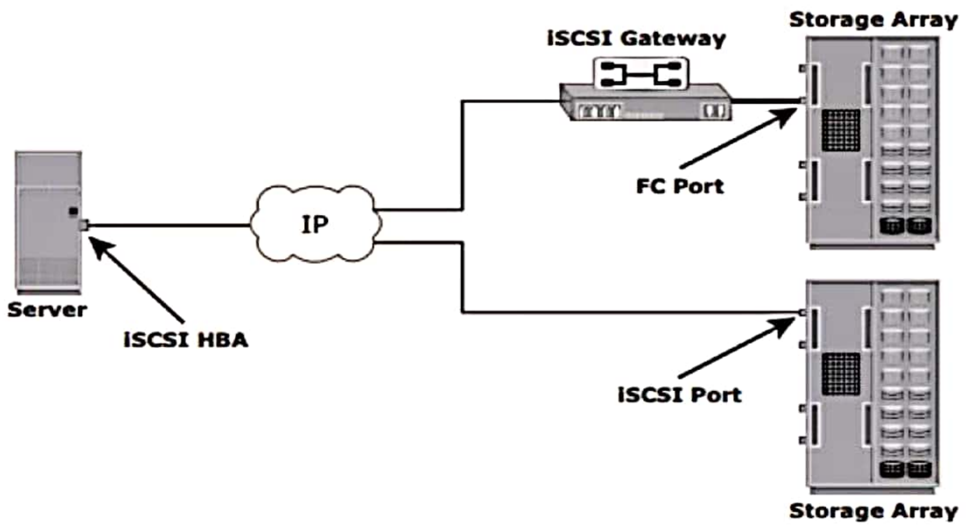


Fig 2.21: iSCSI implementation

Components of iSCSI

- An initiator (host), target (storage or iSCSI gateway), and an IP-based network are the key iSCSI components.
- If an iSCSI-capable storage array is deployed, then a host with the iSCSI initiator can directly communicate with the storage array over an IP network.
- However, in an implementation that uses an existing FC array for iSCSI communication, an iSCSI gateway is used.
- These devices perform the translation of IP packets to FC frames and vice versa, thereby bridging the connectivity between the IP and FC environments.

What is NAS? Explain NAS implementation in details.

What is NAS?

- NAS is an IP based dedicated, high-performance file sharing and storage device.
- Enables NAS clients to share files over an IP network.
- Uses network and file-sharing protocols to provide access to the file data.
- Ex: Common Internet File System (CIFS) and Network File System (NFS).
- Enables both UNIX and Microsoft Windows users to share the same data seamlessly.
- NAS device uses its own operating system and integrated hardware and software components to meet specific file-service needs.
- Its operating system is optimized for file I/O which performs better than a general-purpose server.
- A NAS device can serve more clients than general-purpose servers and provide the benefit of server consolidation.

2.12.1 Components of NAS

- NAS device has *two* key components (as shown in Fig 2.33): **NAS head** and **storage**.
- In some NAS implementations, the storage could be external to the NAS device and shared with other hosts.
- NAS head includes the following components:
  - CPU and memory
  - One or more network interface cards (NICs), which provide connectivity to the client network.
  - An optimized operating system for managing the NAS functionality. It translates file-level requests into block-storage requests and further converts the data supplied at the block level to file data
  - NFS, CIFS, and other protocols for file sharing
  - Industry-standard storage protocols and ports to connect and manage physical disk resources
- The NAS environment includes clients accessing a NAS device over an IP network using file-sharing protocols.

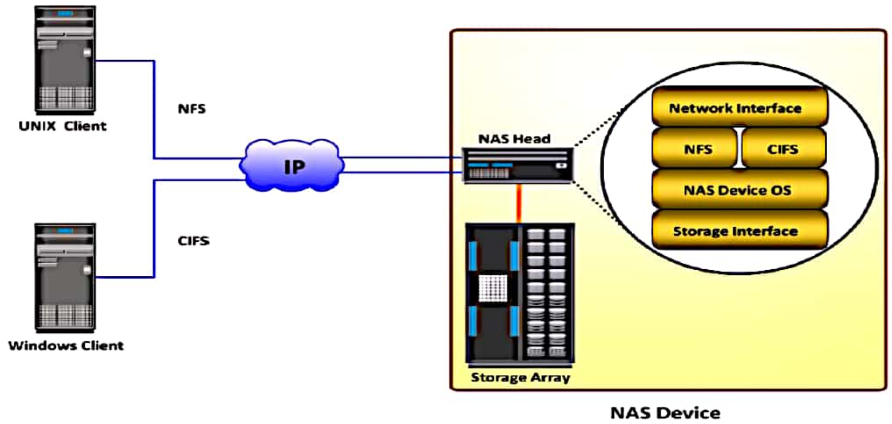


Fig 2.33 Components of NAS

2.12.2 NAS I/O Operation

- NAS provides *file-level data access* to its clients. File I/O is a high-level request that specifies the file to be accessed.
- Eg: a client may request a file by specifying its name, location, or other attributes. The NAS operating system keeps track of the location of files on the disk volume and converts client file I/O into block-level I/O to retrieve data.
- The process of handling I/Os in a NAS environment is as follows:
  1. The requestor (client) packages an I/O request into TCP/IP and forwards it through the network stack. The NAS device receives this request from the network.
  2. The NAS device converts the I/O request into an appropriate physical storage request, which is a block-level I/O, and then performs the operation on the physical storage.
  3. When the NAS device receives data from the storage, it processes and repackages the data into an appropriate file protocol response.
  4. The NAS device packages this response into TCP/IP again and forwards it to the client through the network.
- Fig 2.34 illustrates the NAS I/O operation

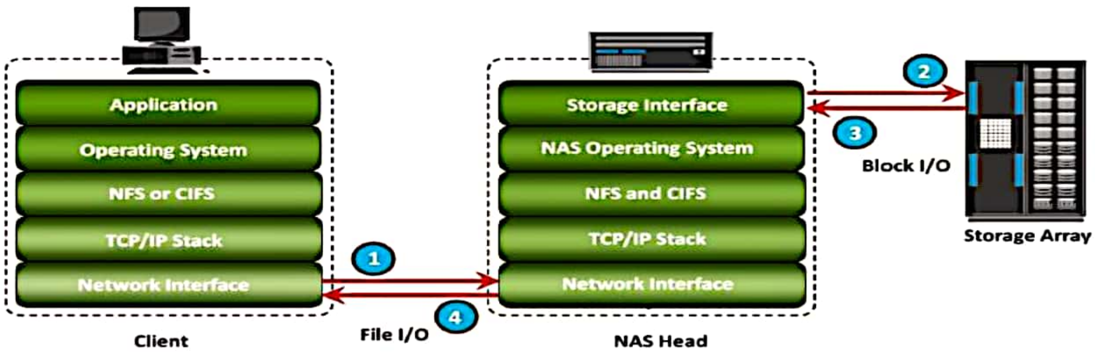


Fig 2.34 NAS I/O Operation

Discuss different iSCSI Topologies with neat diagrams

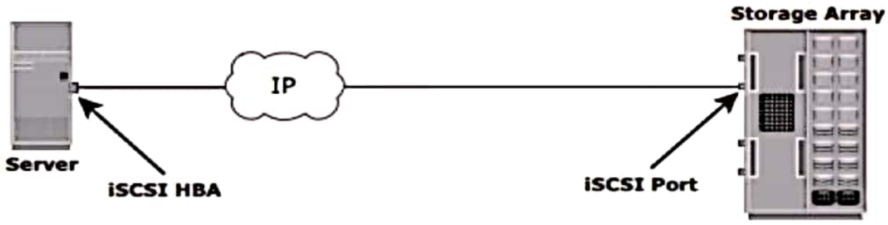
iSCSI Topologies

- Two topologies of iSCSI implementations are **native and bridged**.
- Native topology does not have FC components.
- The initiators may be either directly attached to targets or connected through the IP network.
- Bridged topology enables the coexistence of FC with IP by providing iSCSI-to-FC bridging functionality.
- For example, the initiators can exist in an IP environment while the storage remains in an FC

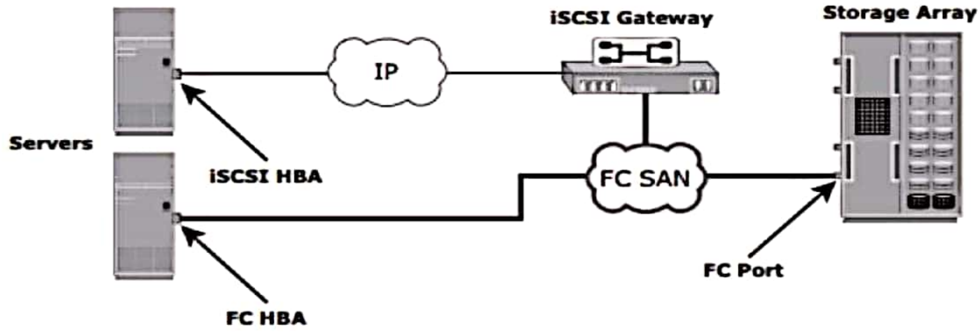
- FC components are not required for iSCSI connectivity if an iSCSI-enabled array is deployed.
- In Fig 2.22(a), the array has one or more iSCSI ports configured with an IP address and is connected to a standard Ethernet switch.
- After an initiator is logged on to the network, it can access the available LUNs on the storage array.
- A single array port can service multiple hosts or initiators as long as the array port can handle the amount of storage traffic that the hosts generate.

Bridged iSCSI Connectivity

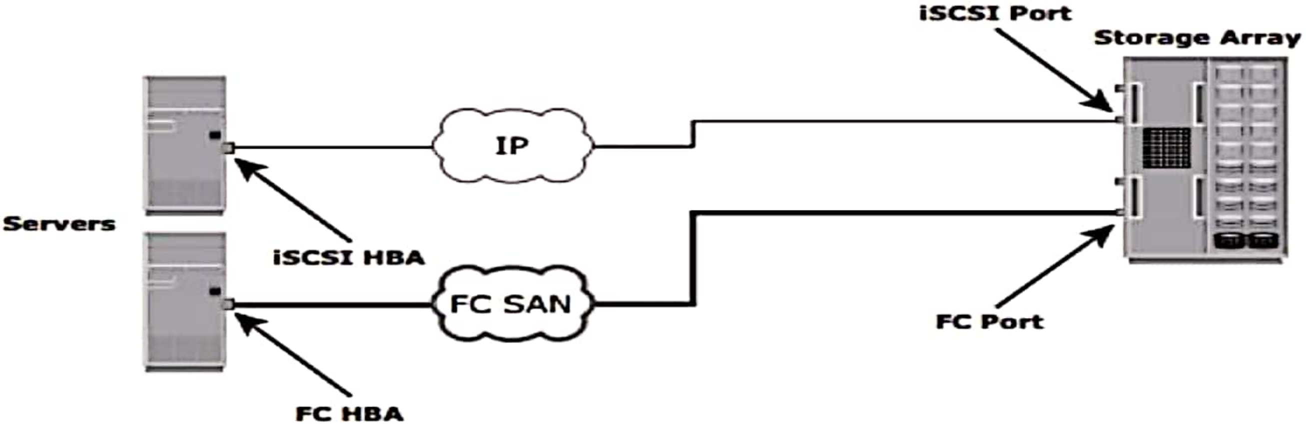
- A bridged iSCSI implementation includes FC components in its configuration.
- Fig 2.22(b), illustrates iSCSI host connectivity to an FC storage array. In this case, the array does not have any iSCSI ports. Therefore, an external device, called a gateway or a multiprotocol router, must be used to facilitate the communication between the iSCSI host and FC storage.
- The gateway converts IP packets to FC frames and vice versa.
- The bridge devices contain both FC and Ethernet ports to facilitate the communication between the FC and IP environments.
- In a bridged iSCSI implementation, the iSCSI initiator is configured with the gateway's IP address as its target destination.
- On the other side, the gateway is configured as an FC initiator to the storage array.
- **Combining FC and Native iSCSI Connectivity:** The most common topology is a combination of FC and native iSCSI. Typically, a storage array comes with both FC and iSCSI ports that enable iSCSI and FC connectivity in the same environment, as shown in Fig 2.22(c).



(a) Native iSCSI Connectivity



(b) Bridged iSCSI Connectivity



(c) Combining FC and Native iSCSI Connectivity

Fig 2.22 : iSCSI Topologies

Write short notes on Fiber channel over Ethernet(FCOE) & its components

FCoE (Fibre Channel over Ethernet)

- Data centers typically have multiple networks to handle various types of I/O traffic — for example, an Ethernet network for TCP/IP communication and an FC network for FC communication.
- TCP/IP is typically used for client-server communication, data backup, infrastructure management communication, and so on.
- FC is typically used for moving block-level data between storage and servers.
- To support multiple networks, servers in a data center are equipped with multiple redundant physical network interfaces — for example, multiple Ethernet and FC cards/adapters. In addition, to enable the communication, different types of networking switches and physical cabling infrastructure are implemented in data centers.
- The need for two different kinds of physical network infrastructure increases the overall cost and complexity of data center operation.
- Fibre Channel over Ethernet (FCoE) protocol provides consolidation of LAN and SAN traffic over a single physical interface infrastructure.
- FCoE helps organizations address the challenges of having multiple discrete network infrastructures.
- FCoE uses the Converged Enhanced Ethernet (CEE) link (10 Gigabit Ethernet) to send FC frames over Ethernet.

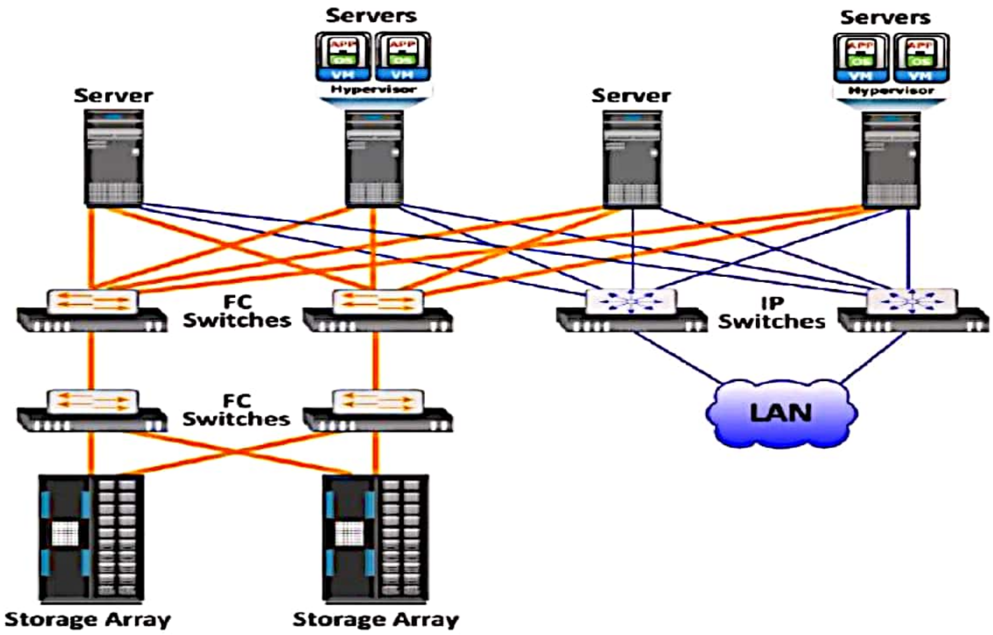


Fig 2.30 Before using FCOE

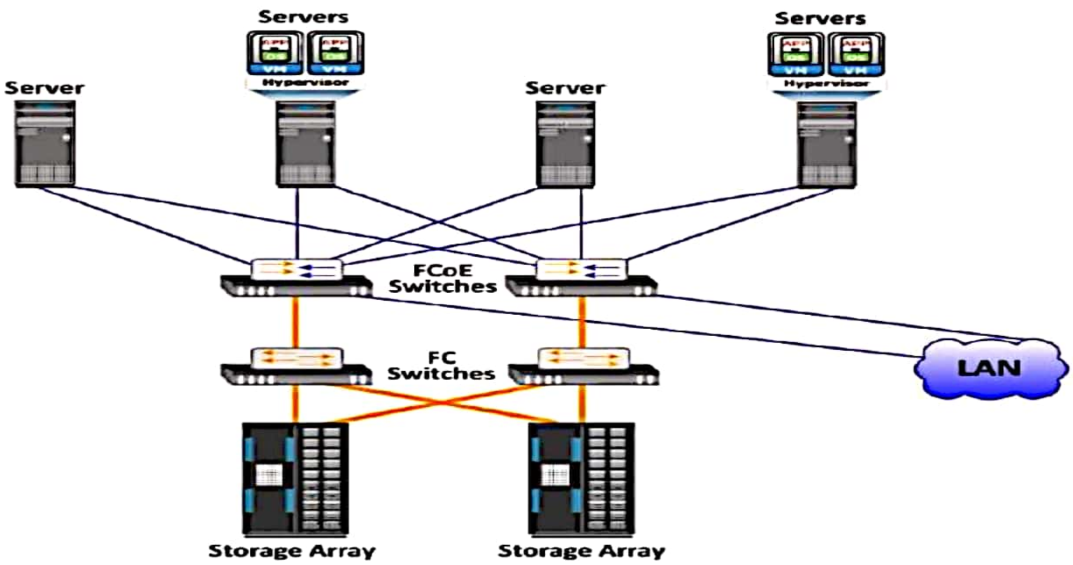


Fig 2.30 After using FCOE

Components of FCOE

The key components of FCOE are :

- Converged Network Adaptors(CNA)
- Cables
- FCOE Switches

Converged Network Adaptors(CNA)

- A CNA provides the functionality of both a standard NIC and an FC HBA in a single adapter and consolidates both types of traffic. CNA eliminates the need to deploy separate adapters and cables for FC and Ethernet communications, thereby reducing the required number of server slots and switch ports.

➢ As shown in Fig 2.31, a CNA contains separate modules for 10 Gigabit Ethernet, Fibre Channel, and FCoE Application Specific Integrated Circuits (ASICs). The FCoE ASIC encapsulates FC frames into Ethernet frames. One end of this ASIC is connected to 10GbE and FC ASICs for server connectivity, while the other end provides a 10GbE interface to connect to an FCoE switch.

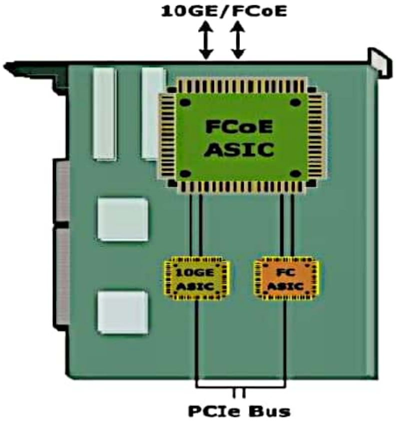


Fig 2.31 Converged Network Adapter

Cables

➢ There are two options available for FCoE cabling:

1. Copper based Twinax
2. standard fiber optical cables.

➢ A Twinax cable is composed of two pairs of copper cables covered with a shielded casing. The Twinax cable can transmit data at the speed of 10 Gbps over shorter distances up to 10 meters. Twinax cables require less power and are less expensive than fi ber optic cables.

➢ The Small Form Factor Pluggable Plus (SFP+) connector is the primary connector used for FCoE links and can be used with both optical and copper cables.

FCOE SWITCHES:

➢ An FCoE switch has both **Ethernet switch** and **Fibre Channel switch** functionalities.

➢ As shown in Fig 2.32, FCoE switch consists of:

1. *Fibre Channel Forwarder (FCF),*
2. *Ethernet Bridge,*
3. set of Ethernet ports
4. optional FC ports

➢ The function of the FCF is to encapsulate the FC frames, received from the FC port, into the FCoE frames and also to de-encapsulate the FCoE frames, received from the Ethernet Bridge, to the FC frames.

➢ Upon receiving the incoming traffic, the FCoE switch inspects the **Ethertype** (used to indicate which protocol is encapsulated in the payload of an Ethernet frame) of the incoming frames and uses that to determine the destination.

- If the Ethertype of the frame is FCoE, the switch recognizes that the frame contains an FC payload and forwards it to the FCF. From there, the FC is extracted from the FCoE frame and transmitted to FC SAN over the FC ports.
- If the Ethertype is not FCoE, the switch handles the traffic as usual Ethernet traffic and forwards it over the Ethernet ports.

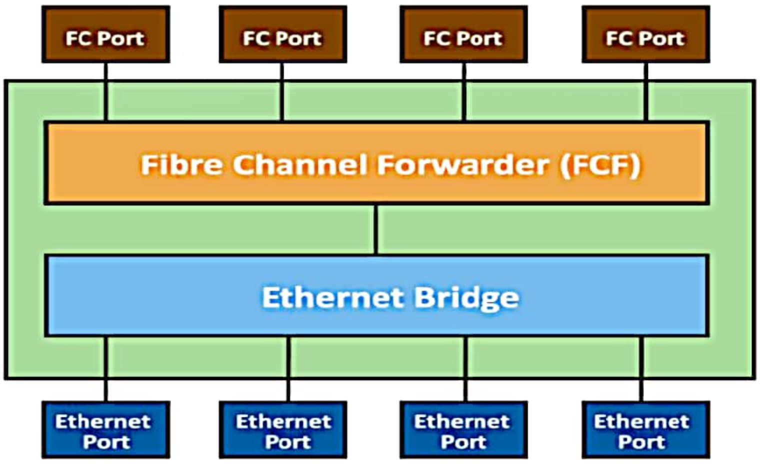


Fig 2.32 FCoE switch generic architecture