Fibre Channel SAN

Dr Peadar Grant

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1 Fibre Channel

Fibre Channel (FC) SAN normally involves the use of **Fibre Channel Protocol (FCP)** over an optical fibre network.

1.1 Key concepts

- Block devices exposed as LUNs on targets that initiators connect to.
- FC normally encapsulates SCSI commands.
- FCP is analogus to IP in ways, and has its own addressing schemes etc.
- Assume that the FC network is solely for FCP stroage traffic.
- FC normally uses hardware HBA.

1.2 FC SAN Components

Host-Bus Adapter (HBA): connects the host to the FC SAN.

- Normally appears as a standard disk controller to the operating system
- Similar to how hardware RAID controller encapsulates a RAID set
- *Note that the fibre channel network is entirely separate from the host's LAN connection(s*

Fabric components: such as hubs, switches, etc. Specific to Fibre Channel!

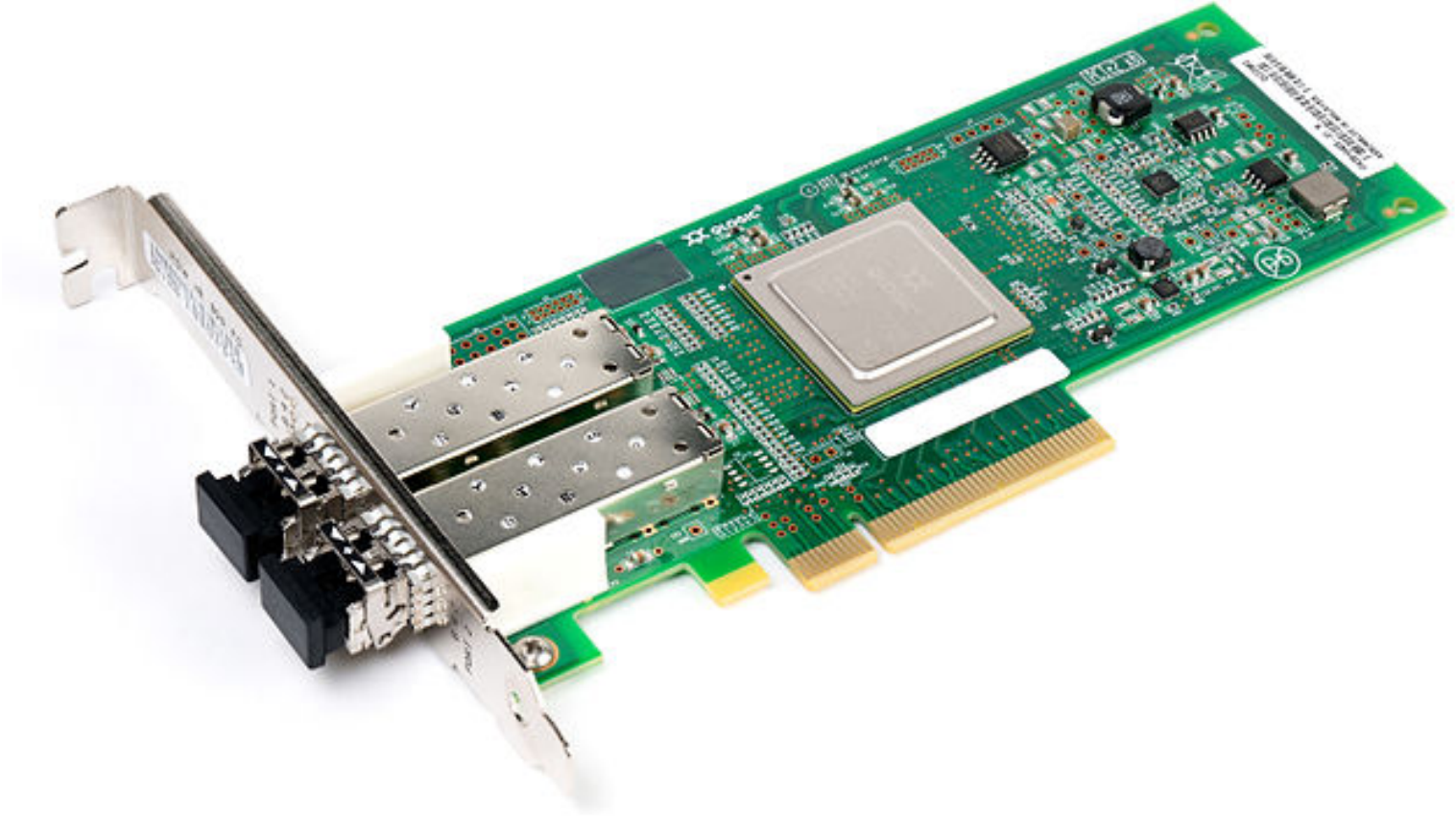

Figure 1: FC HBA

1.3 FC Connections

Fibre Channel SAN usually involves optical fibre transmission:

- Both multi-mode (MMF) OM1, OM2, OM3 types and single-mode used.
  - Multi-mode used within data centre / suite (under 500m)
  - Single-mode used for longer distances (over 500m).
- The standard SC, LC, ST connectors are often seen.
- Confusingly, fibre channel can also be carried over copper.

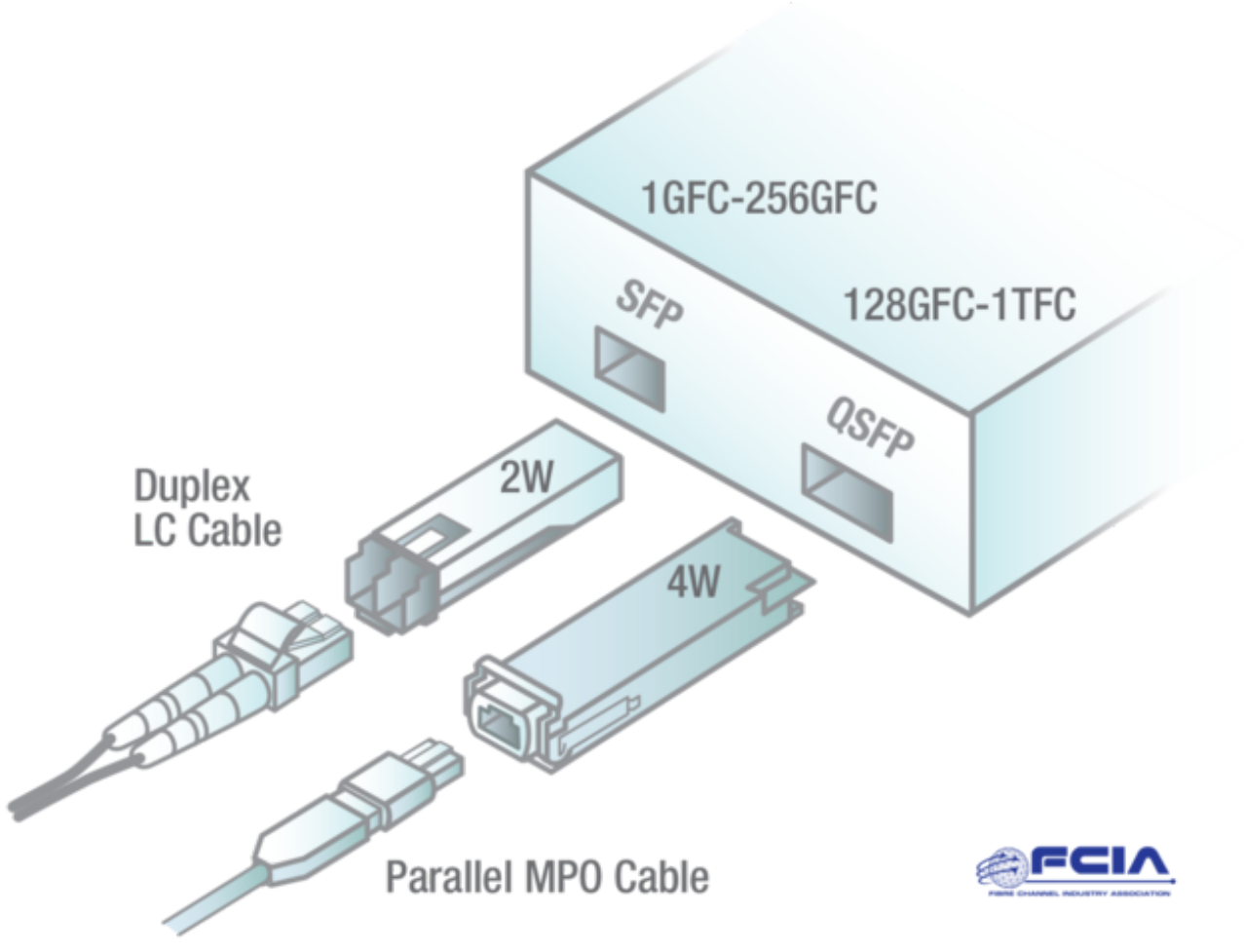

Figure 2: Fibre Channel Connectors

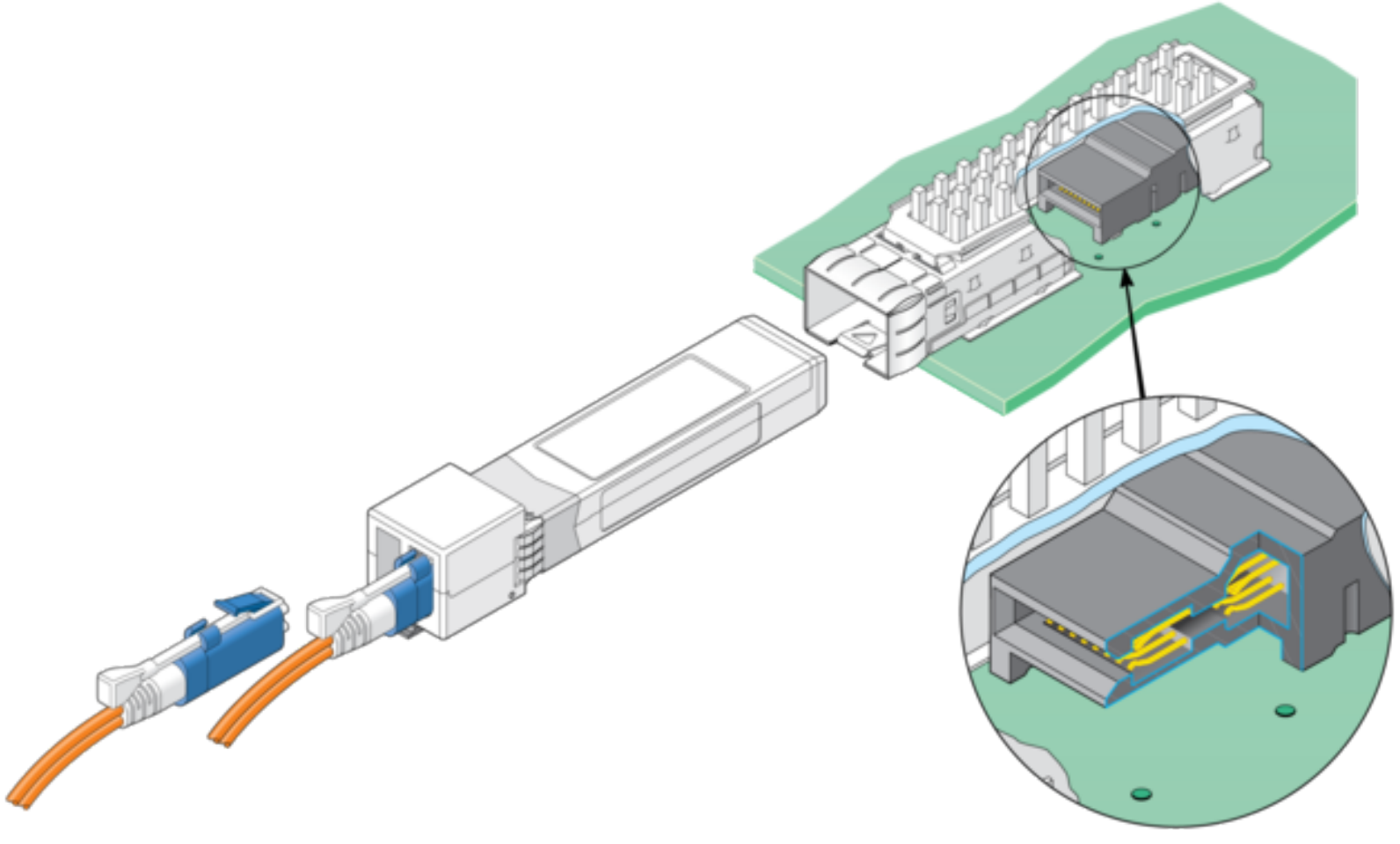

Figure 3: Fibre Channel Connectors

2 FC Fabric types

2.1 Point-to-Point

The simplest fabric is a point-to-point where a single host node connects to a single storage node. Both the host and storage nodes ports are N_ports (node ports).

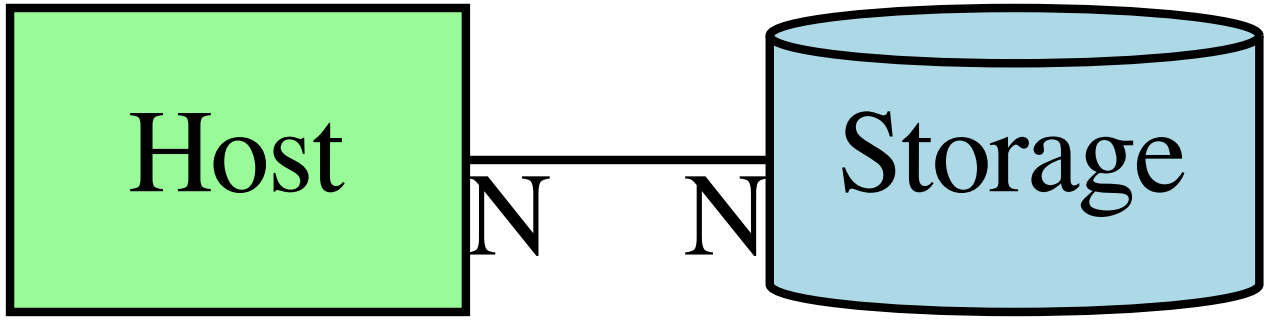

Figure 4: Point-To-Point

These are sometimes seen where a single storage appliance has multiple node (N) ports, each of which is connected to an N port on a host.

2.2 Switched fabric

Most SAN implementations involve a switched fabric, Figure 5.

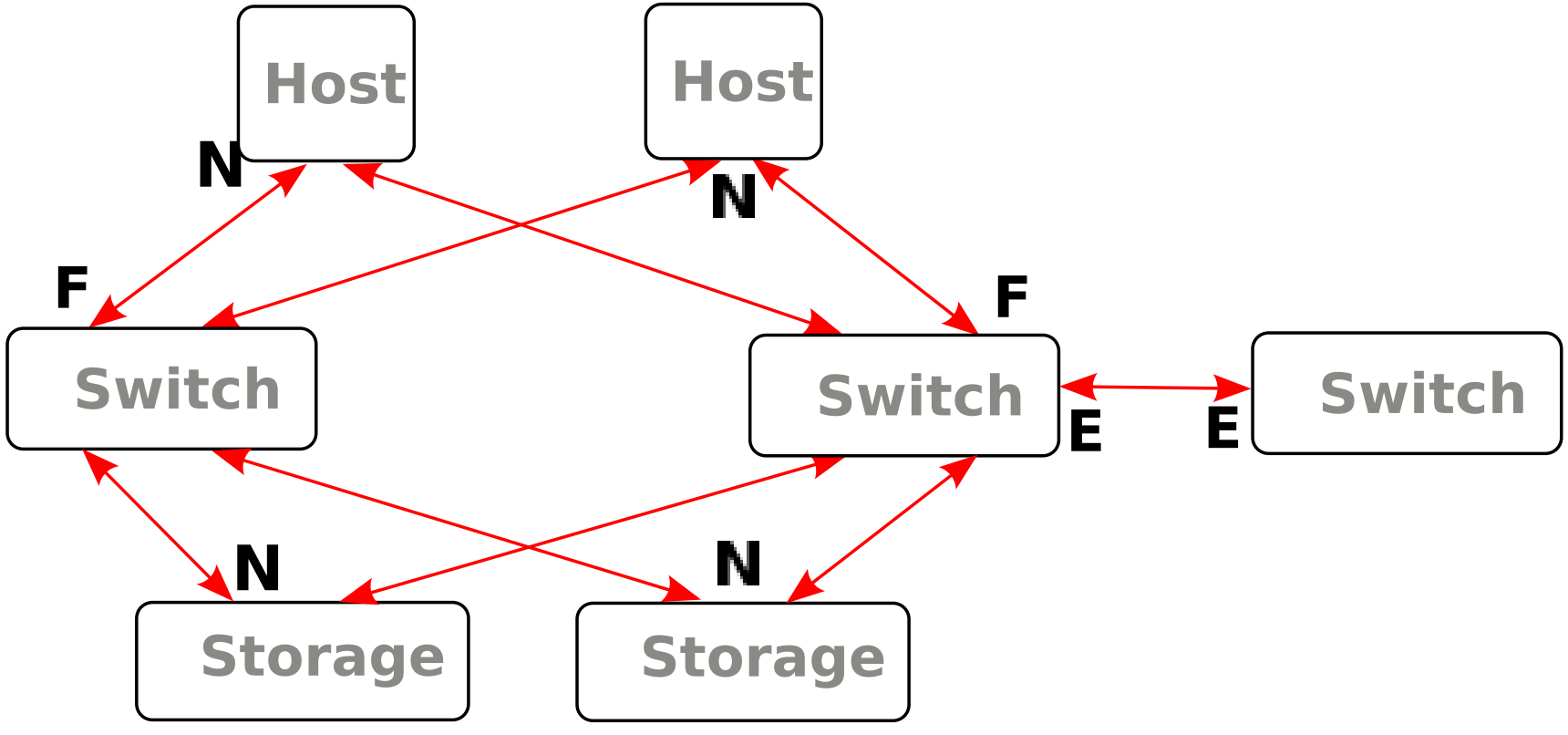

Figure 5: FC switched fabric

2.3 Port types

Within a switched fabric, ports are designated as different types. Main types are:

N_port (node port) connects either to another N_port as in this example or to an F port on a switch.

F_port (fabric port) on a switch connects to an N_port on node.

E_port (expansion port) on a switch connects to an E_port on another switch.

- Link between two switches is called an **inter-switch link** (ISL).

G_port can act as either an *F* or *G* port.

We say that a fabric has a number of **tiers** with an *n*-tier fabric requiring traffic to pass through up to *n* switches.

3 FC Layers

Fibre Channel is conceptually divided into 5 layers (numbered 4-0):

FC-4 **Protocol-mapping** layer, where upper level protocols ULPs such as SCSI, IP, and others are encapsulated into Information Units (IUs).

FC-3 **Common services** layer, thin layer that could implement functions like encryption or RAID redundancy algorithms; multiport connections; not used.

FC-2 **Signaling Protocol**, defined by the Fibre Channel Framing and Signaling 4 (FC-FS-5) standard, consists of the low level Fibre Channel network protocols; port to port connections;

FC-1 **Transmission Protocol**, which implements line coding of signals;

FC-0 **physical layer**, includes cabling, connectors etc

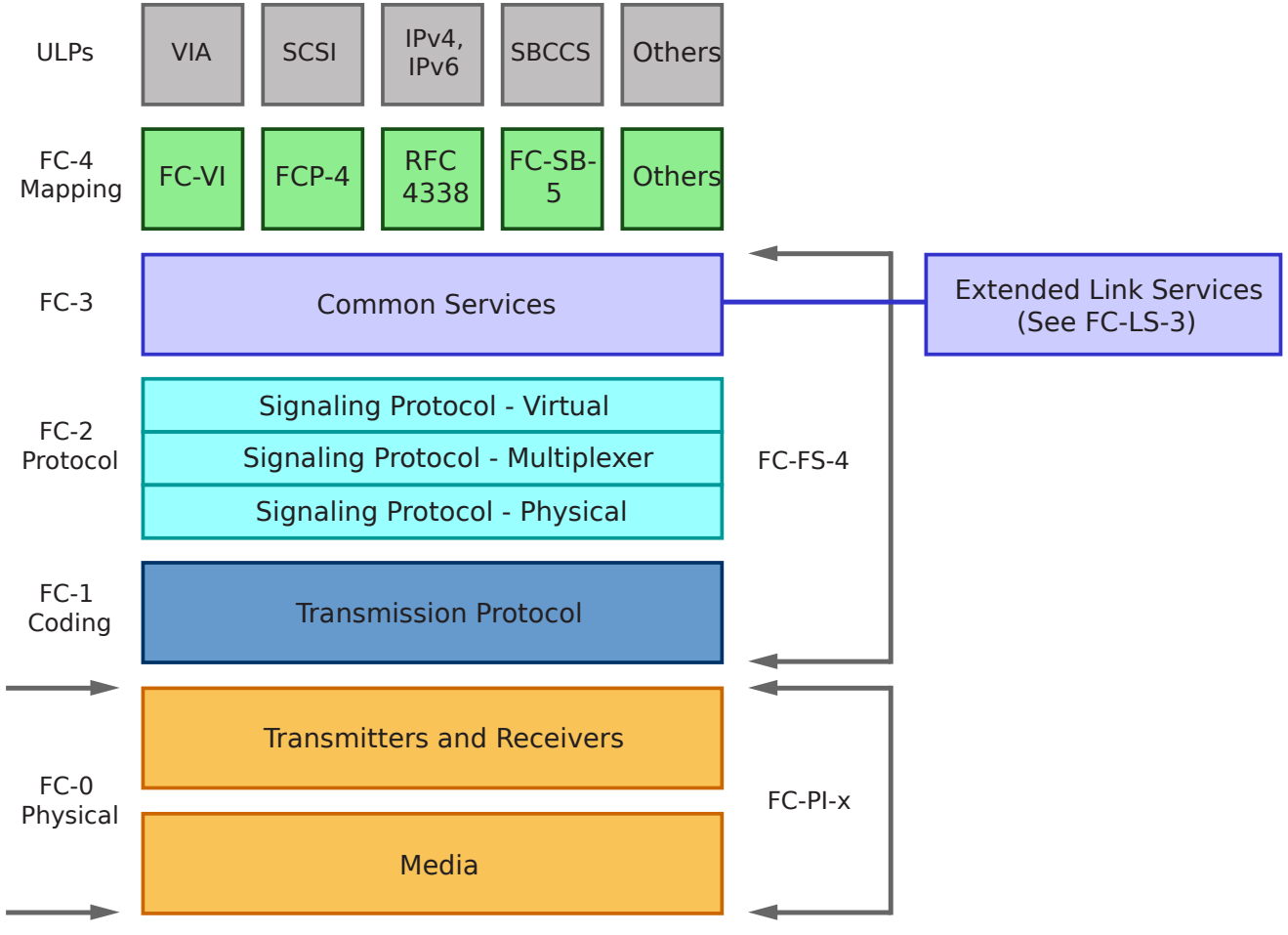

Figure 6: Fibre Channel Layers

4 Encapsulation

FC SAN encapsulates SCSI data in FC frames.

4-bytes start-of-frame

24-byte frame header including source and destination addresses (specific to FC)

2112-byte data field consisting of:

- **64-byte header (optional)**
- **2048-byte data payload** containing SCSI commands (just as with iSCSI in IP SAN)

4-byte CRC error check

4-byte end-of-frame

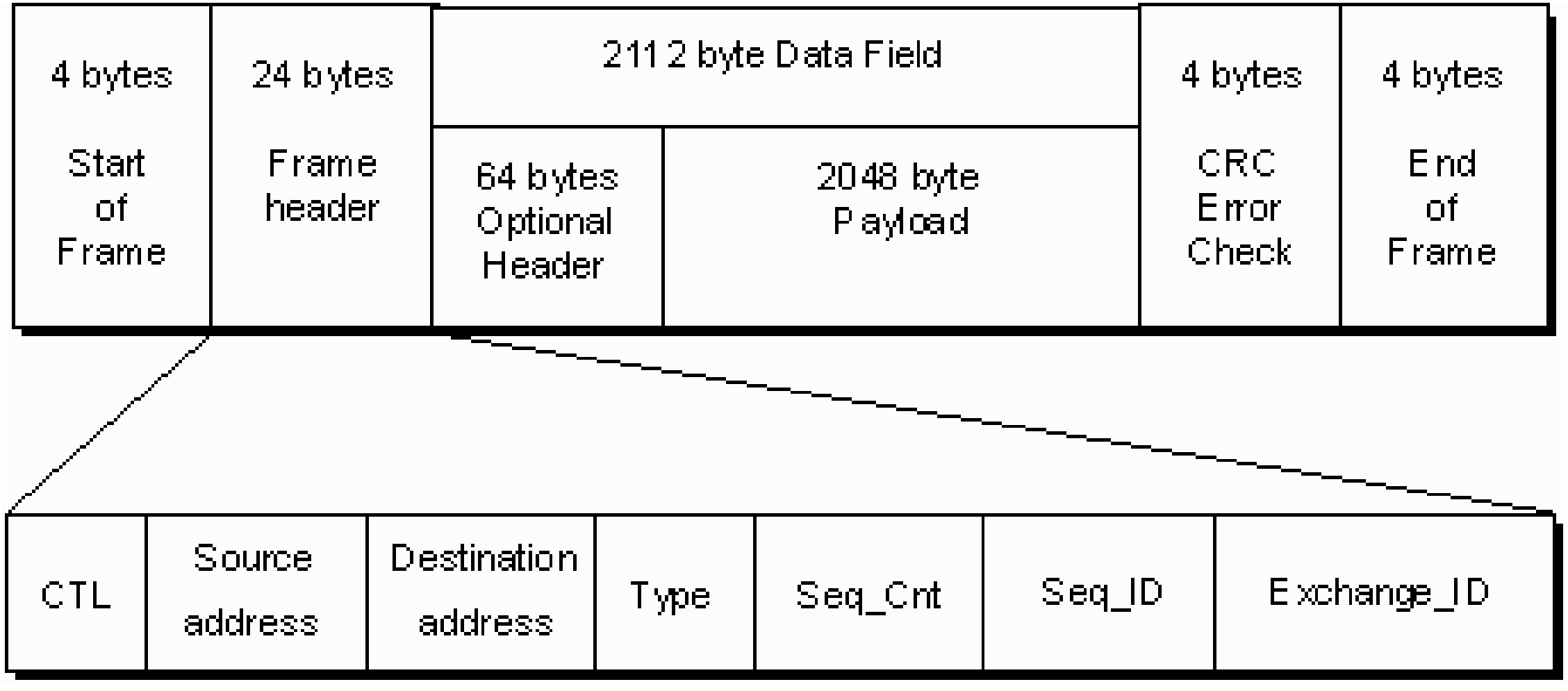

Figure 7: FC frame

5 FC Addressing

As we can see from the FC frames, we need addresses to identify the source and destination of FC traffic. Like IP over Ethernet, FC has two different types of addresses:

5.1 FC address

FC addresses are 24-bit dynamically assigned addresses:

Domain ID (8-bit) is a unique number assigned to each switch in fabric. Only 239 addresses available as some reserved for fabric management services.

Area ID (8-bit) denotes a group of ports on one switch (such as a single card)

Port ID (8-bit) port within the area ID within the domain ID.

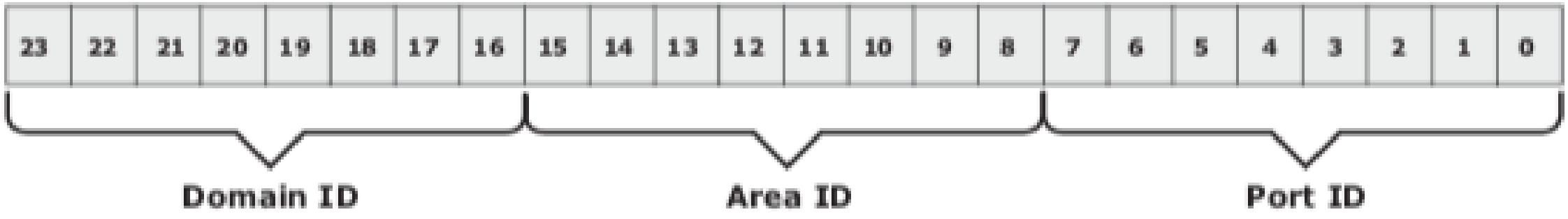

Figure 8: FC address (EMC ISM book)

5.2 Fabric address space

Maximum number of nodes in switched fabric:

$$239 \text{ domains} \times 256 \text{ areas} \times 256 \text{ ports} = 15663104 \quad (1)$$

Address assignment:

- FC address is automatically assigned when an *N* port logs on to the fabric.
- Like DHCP-assigned IP address but deterministic.

5.3 WorldWide Names (WWNs)

WorldWide Names (WWNs) are FC equivalent of MAC addresses:

- They are considered fixed and normally set/burned in in factory.
- WWNs are mapped to FC addresses using the Name Server.
- Opposite to IP networking, we often want to find devices using WWNs which are resolved to FC addresses.

World Wide Name - Array															
5	0	0	6	0	1	6	0	0	0	6	0	0	1	B	2
0101	0000	0000	0110	0000	0001	0110	0000	0000	0000	0110	0000	0000	0001	1011	0010
Format Type	Company ID 24 bits						Port	Model Seed 32 bits							

World Wide Name - HBA															
1	0	0	0	0	0	0	0	c	9	2	0	d	c	4	0
Format Type	Reserved 12 bits			Company ID 24 bits						Company Specific 24 bits					

Figure 9: FC world wide name (WWN)

6 Fabric services

Each switch provides a number of services at fixed FC addresses (drawn from the reserved range), Figure 10.

Fabric Login Server (FFFFFE) node login (connection) to the fabric.

Name Server (FFFFFC) tracks FC address to WWN associations. Like ARP in IP.

- Synchronises automatically with name servers in other switches in fabric.
- *Formerly called Distributed Name Service but was ambiguous since DNS abbreviation means Domain Name Service which is entirely different.*

Fabric Controller (FFFFFD) updates nodes and other switches when changes in the fabric occur, likea device or link being added or removed.

Management Server (FFFFFA) allows managment software to monitor and control the operation of the fabric.

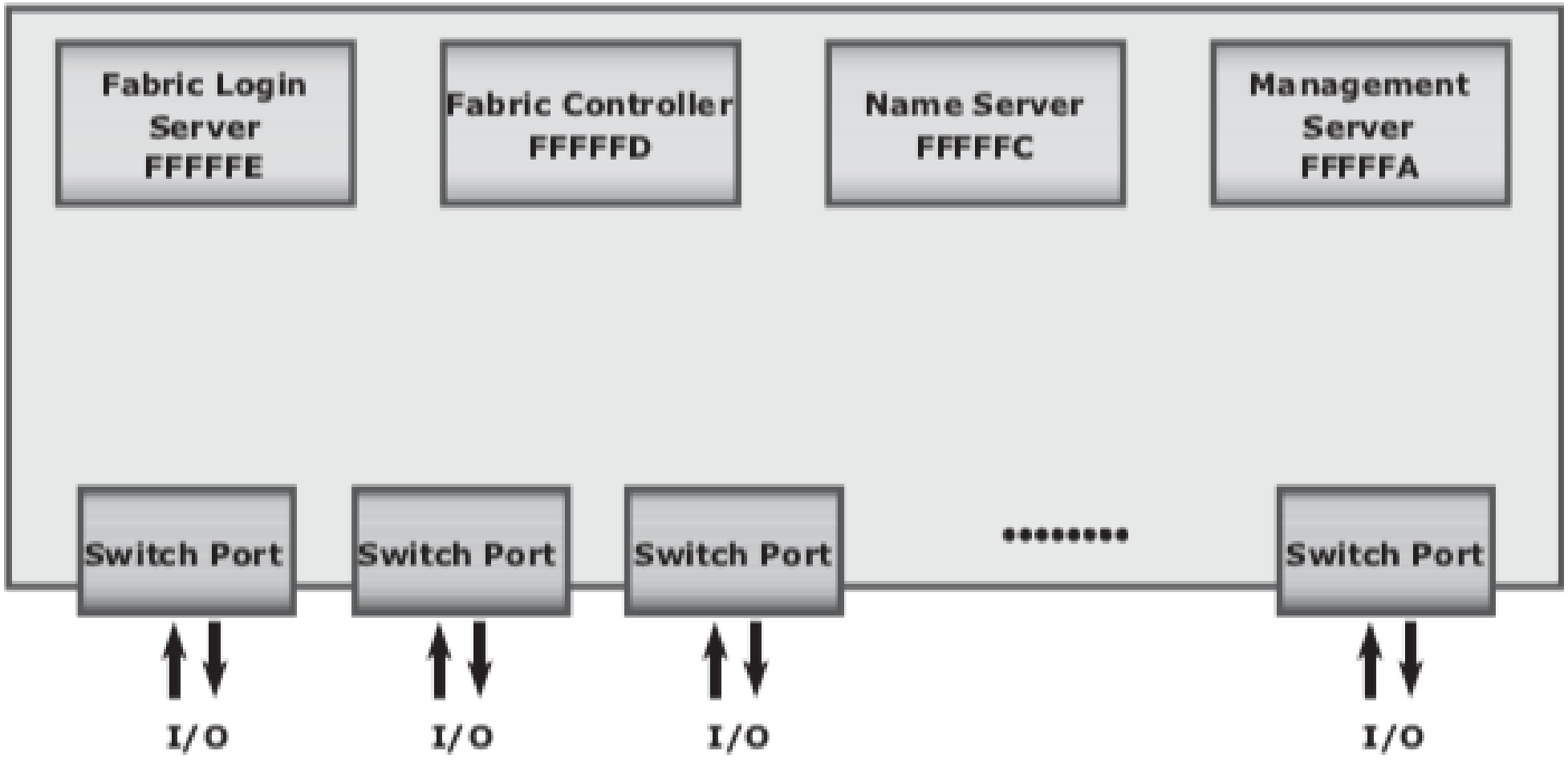

Figure 10: FC fabric services (EMC ISM book)

6.1 State Change Notifications (SCN)

When changes occur the Fabric controller distributes:

Registered State Change Notifications (RSCNs) to nodes attached to its own ports.

Switch Registered State Change Notifications (SW-RSCNs) to other switches in the fabric. This causes the name servers to update.

6.2 FC Login types

Fabric Login (FLOG) when an *N* port (on a host / storage device) connects to an *F* port (on a switch):

- During FLOG, WWN of node and port are passed to login server (FFFFFE).
- Login server returns FC address to node.
- Login server registers WWN with FC address so node can be found by WWN.

Port login (PLOG) when an *N* port on an initiator makes a connection to the *N* port on a target through the fabric. (Must have completed FLOG first.)

Process Login (PRLI) which establishes the Upper Layer Protocol (ULP) (such as SCSI) between two *N* ports.

7 Zoning

Zoning is where ports in the fabric are logically grouped together, . Zoning can provide security benefit, avoid accidental mis-configuration and increase performance. Conceptually like ethernet VLAN.

??FC Zoningfc-zoning

- When zoning is used, a port may be a member of one or more zones. Nodes only see other nodes that are same zone as themselves. A zone can span multiple switches in the fabric.
- Without zoning, all nodes get all RSCNs. In zoned FC, RSCNs get sent only to nodes in zone. Cuts down on the amount of fabric managament traffic if done correctly.
- Zone set comprises multiple zones. Can be activated / deactivated as single unit within fabric. Only one zone can be active at one time.

7.1 Zone types

Port zoning where switch ports are grouped into zone(s). (Easy replacement of failed devices.)

WWN zoning where WWNs are grouped into zones. (Allows physical movement.)

Mixed zoning combining both. E.g. host WWN and storage port or vice-versa.

Single HBA zoning each HBA has own zone created and relevant storage added to it.

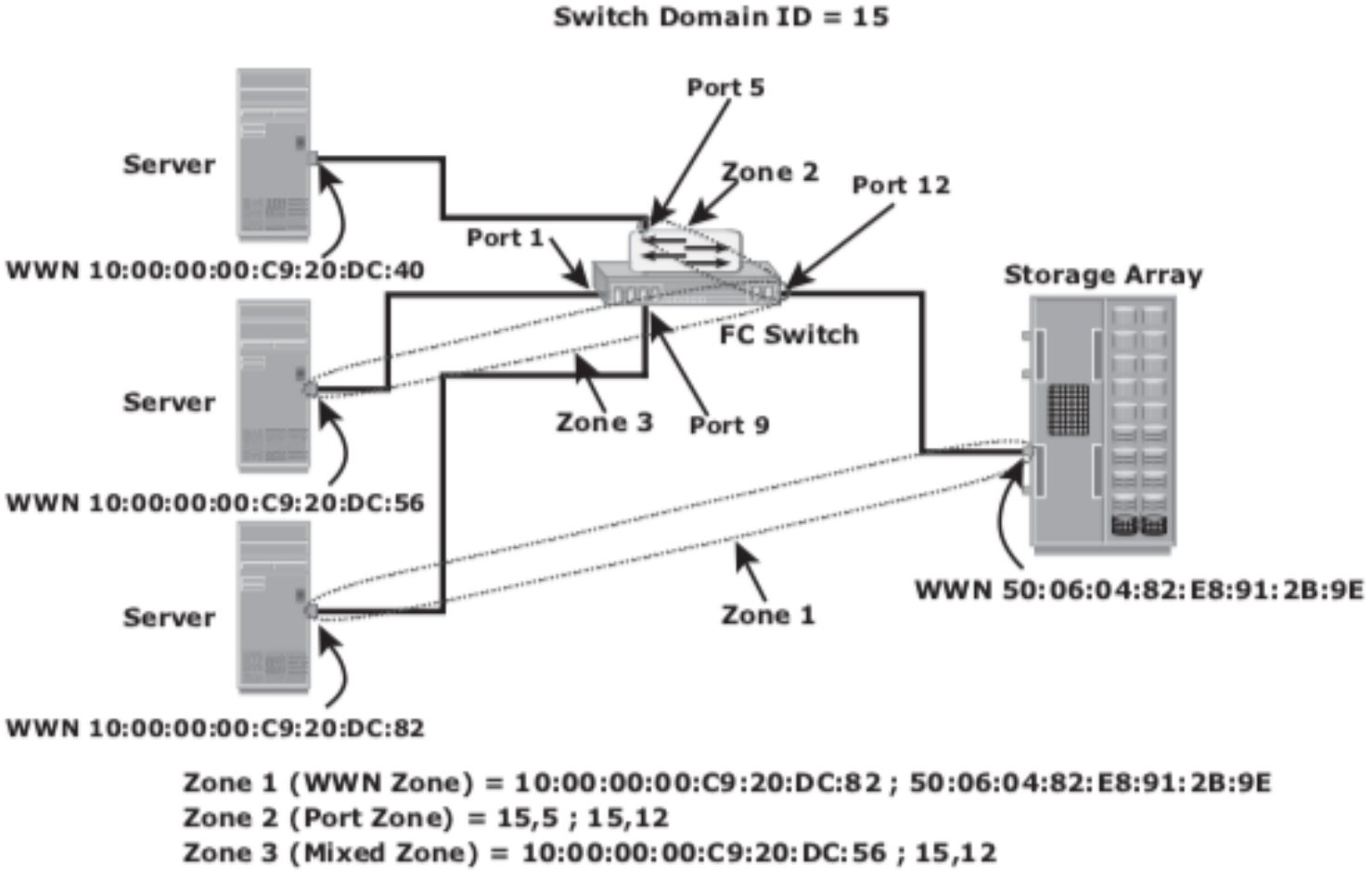

Figure 11: FC Zone types (EMC ISM book)

8 FC Topologies

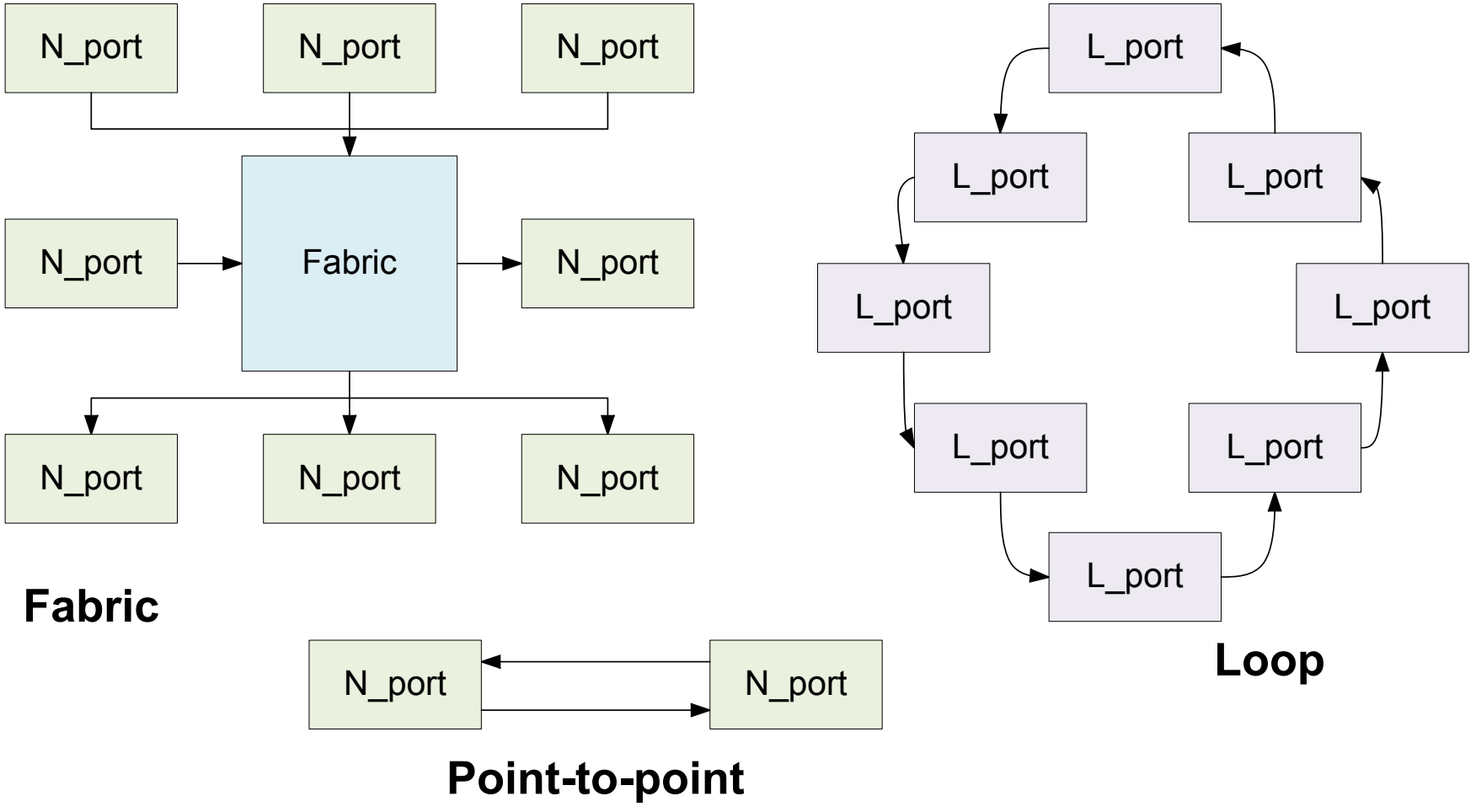

Figure 12: FC topologies

8.1 Single-switch

Single switch topologies are now very common:

- Most FC deployments are in data centre environments where overall distance is low.
- Increasing number of ports per switch.
- Cheap and easy to administer. No ISLs, simple fabric.

8.2 Mesh fabric

A mesh fabric involves multiple switches connected such that each is connected redundantly to other switches, .

Full mesh where any switch in the fabric is linked to all others directly.

Partial mesh where crossing multiple ISLs are necessary to get to some switches.

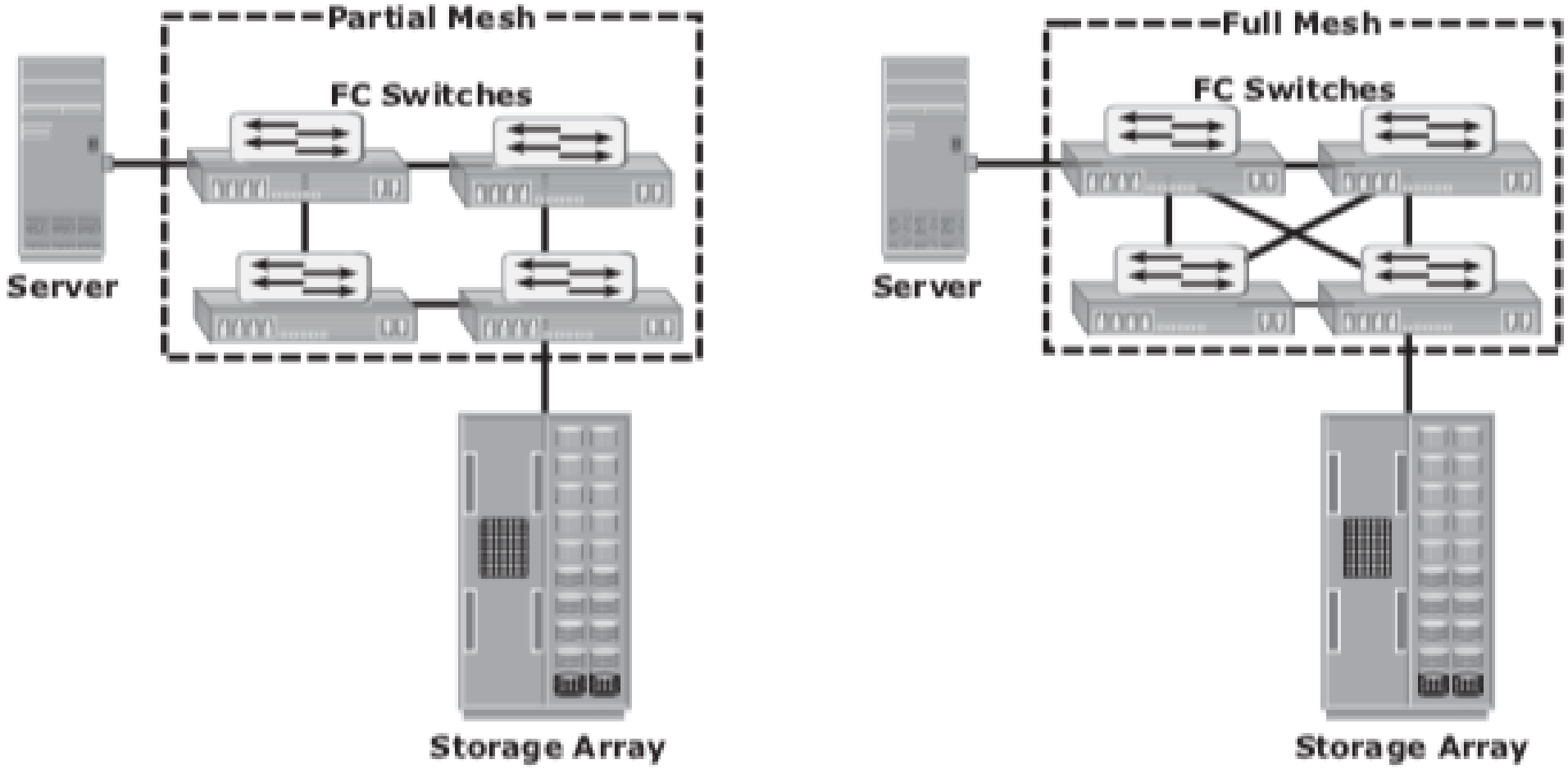

Figure 13: Mesh topologies

8.3 Core-Edge Fabric

Core-edge fabrics involve a core tier that connects storage device to edge switches that connect to host devices, . Many variations on this theme.

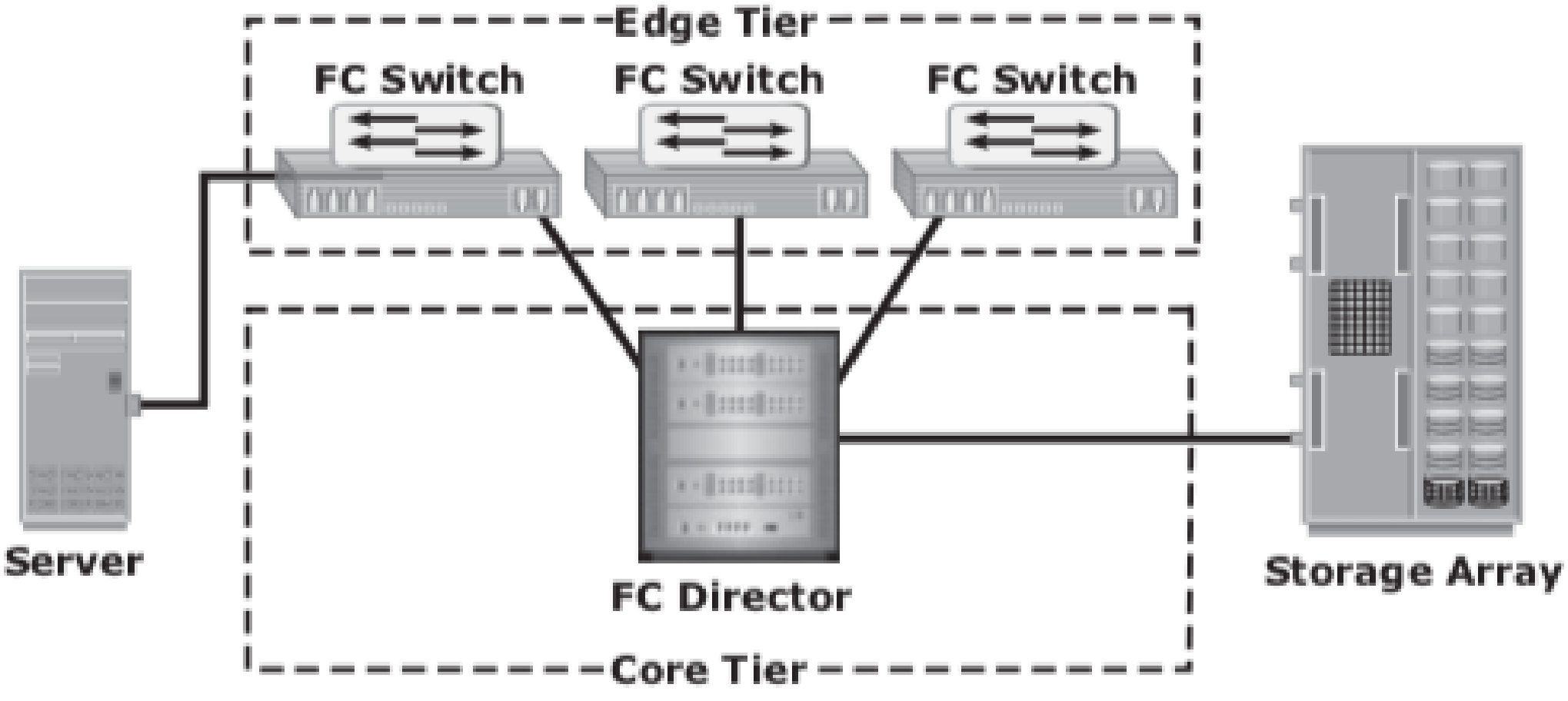

Figure 14: Single-core topology (EMC ISM book)