FCoE Direct End-Node to End-Node (aka FCoE VN2VN)

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Abstract

- A new concept has been standardization by the Fibre Channel (T11) standards committee; it is called FCoE VN2VN (aka Direct End-Node to End-Node)
- T11 previously standardized the FCoE specification (which defines the encapsulation of Fibre Channel frames within Ethernet Frames – herein called the Base protocol) and has extended that specification to permit FCoE connections DIRECTLY between FCoE End-Nodes (herein called VN2VN)
- This tutorial will show the fundamentals of the extended FCoE concept that permits it to operate without FC switches or FCoE Switches (aka FCFs) and will describe how it might be exploited in a Data Center environment

Agenda

- Introduction
- FCoE (Base) & FCoE (VN2VN)
  - FCoE (Base) Fabrics & Convergence
  - FCoE (VN2VN)
- Architecture
- Discovery & Link Instantiation
  - With FCFs
  - Direct End-to-End (w/o FCFs)
- Topologies
  - Without FCFs (VN2VN)
- Scenarios
  - **Without FCFs (VN2VN)**
- Summary

Introduction

- This presentation provides an overview of a new standard called (herein) FCoE Direct End-Node to End-Node (aka FCoE VN2VN)
  - This is a Lossless Ethernet connection directly between Adapters' Virtual N_Ports
  - This will be contrasted with the Basic FCoE -- herein called FCoE (Base)
- One should think about FCoE VN2VN as placing the FCoE (Base) protocol (which is a FC protocol) on a Lossless Ethernet without the additional FCoE (Base) requirement of FCoE Switches -- known as FC Forwarders (FCFs)
  - Connections are through only (Lossless) Ethernet Switches or via a single wire Point-to-Point
- The required "Lossless Ethernet" links have been defined in IEEE 802 standards
- The VN2VN protocol is has been defined in the INCITS Fibre Channel (T11) technical committee (FC-BB-6 Ad Hoc Work Group)

Background -- FCoE (Base) is a Compatible Alternative to FC

- **FCoE stands for FC over Ethernet**
- **The basic FCoE (Base) was defined as an alternative network structure for carrying FC protocols**
- **FCoE requires specific Ethernet capabilities to be implemented**
  - Lossless switches and fabrics (e.g., supporting IEEE 802.3 PAUSE) configurations are required
  - Jumbo frame support is strongly recommended (not a standard, but widely available)
  - **Deployments of FCoE should utilize the advances in Ethernet currently specified in IEEE 802.1, specifically:**
    - Priority-based Flow Control (PFC) →802.1Qbb
    - Enhanced Transmission Selection (ETS) → 802.1Qaz
    - DCB (capability) eXchange (DCBX) Protocol → 802.1Qaz
    - Congestion Notification (802.1Qau),
  - **Possible** future → Multi-pathing (IETF– TRILL, IEEE 802.1aq SPB, et.al.)
  - **These 802.1 advance capabilities are important for Converged Flows (Messaging, Clustering and Storage)**

    This set of functions is called DCB -- Data Center Bridging
- FCoE (Base) Fabrics require a **DCB** Lossless Ethernet Switch that understands & supports DCB & FC protocols – These Switches are called **FCF**s (FCoE Forwarders)

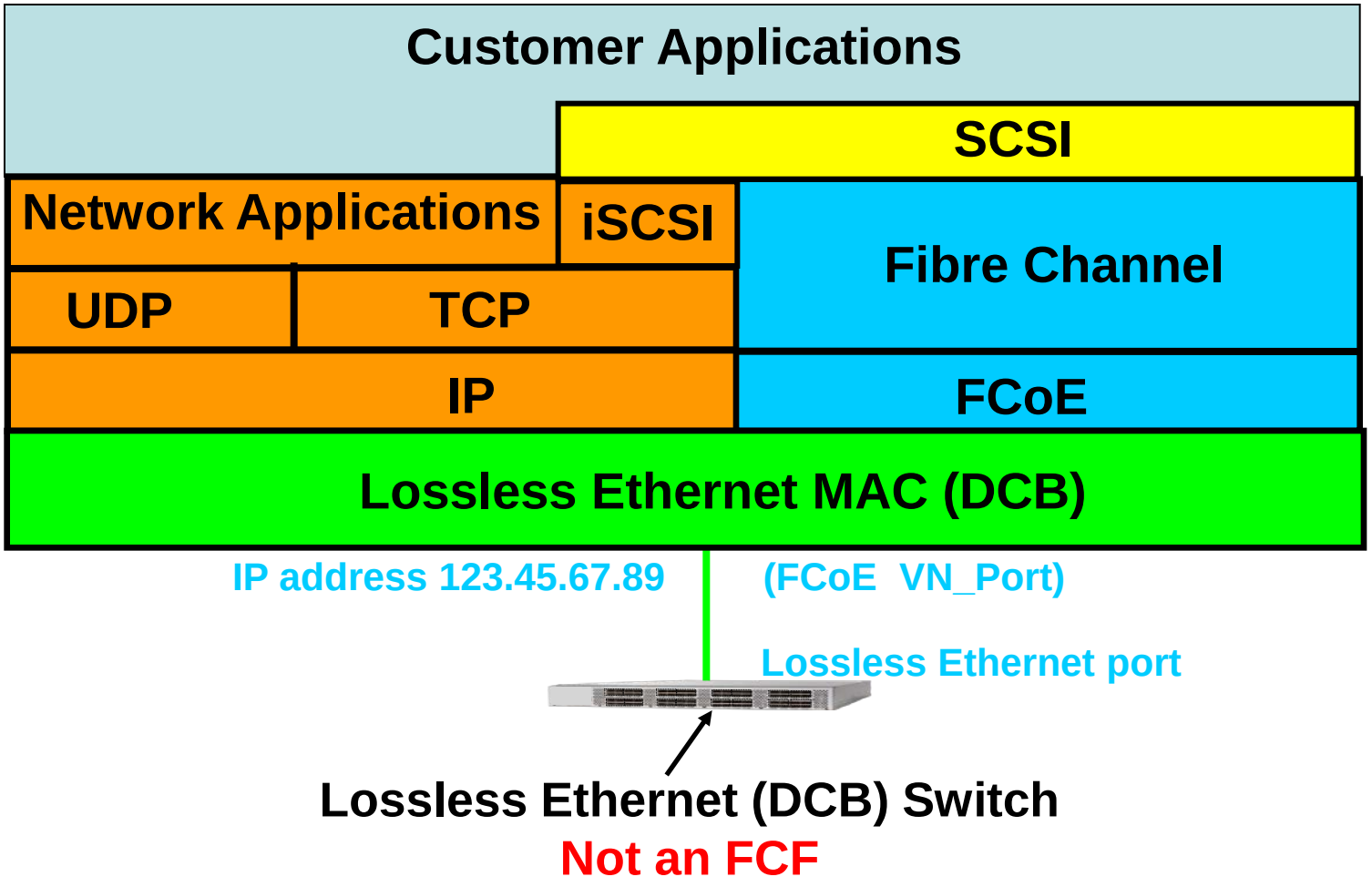
FCoE VN2VN
(Virtual N_Port to Virtual N_Port)

- FCoE VN2VN uses a Lossless Ethernet connection between End-Node Adapters' VN_Ports
- Other than Ethernet Cables, only DCB Ethernet switches (w/o FCF capabilities) may exist between the End-Nodes (VN_Ports) – Therefore, the connection maybe either a:
  - Switched Lossless Ethernet connection (through DCB switches)

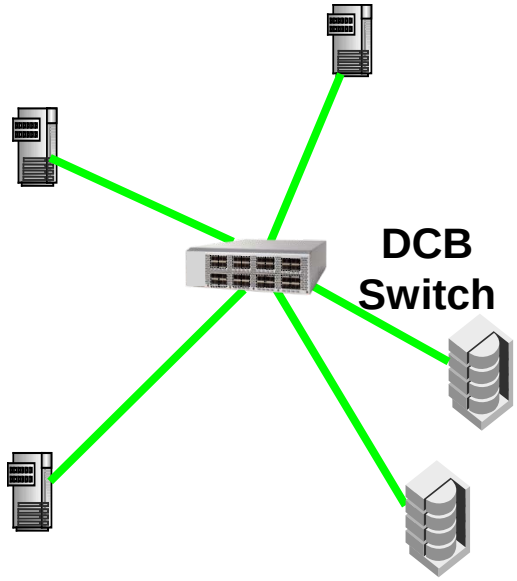
  or
  - Point to Point Lossless Ethernet Wire connection
- FCoE VN2VN permits FCoE networks to be built without any FC Switches or FCoE Switches (aka FCFs)
- FC Data Flow (& Packets) will flow End to End as if they were flowing over a direct (point to point) FC link
  - After connection, must operate identically on a VN2VN connection as on a direct FC link
- No Fibre Channel services or advanced features (e.g. Name services, Zoning, virtual fabrics, IFR, security, etc.) are provided in the network, However:
  - Use of VLANs, and ACLs, can help security issues
  - Security can also be enhanced via FC-SP protocols
  - Storage arrays that have port and LUN masking will also enhance security

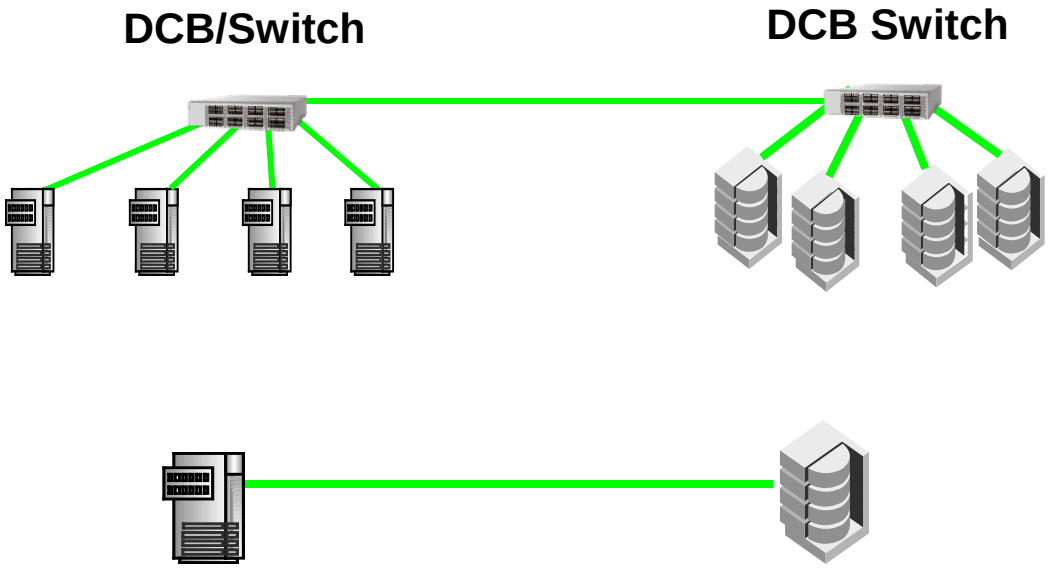
Connections to a DCB Switch

- **Fibre Channel is carried over lossless Ethernet as a L3 protocol**



The Simple VN2VN Interconnect

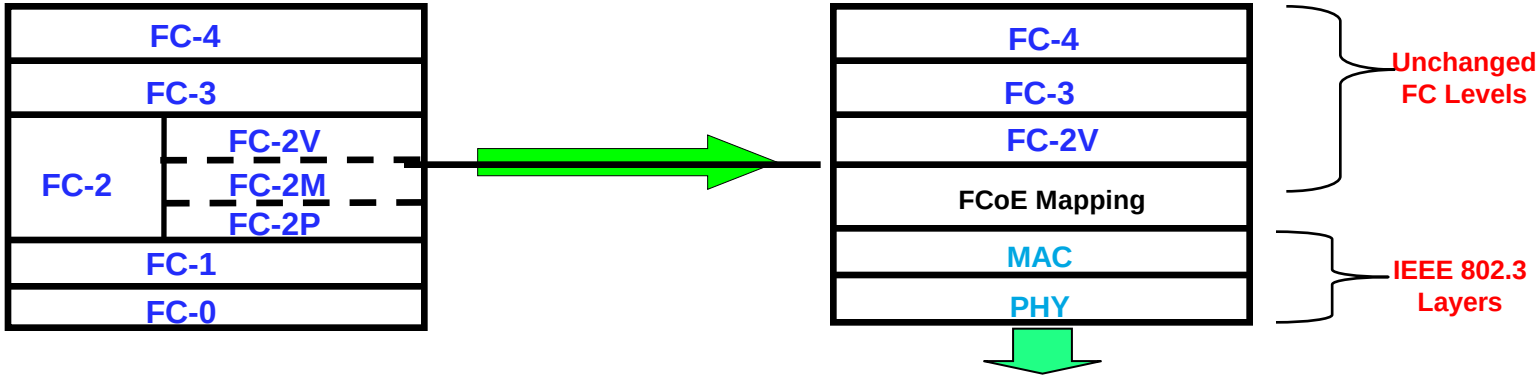




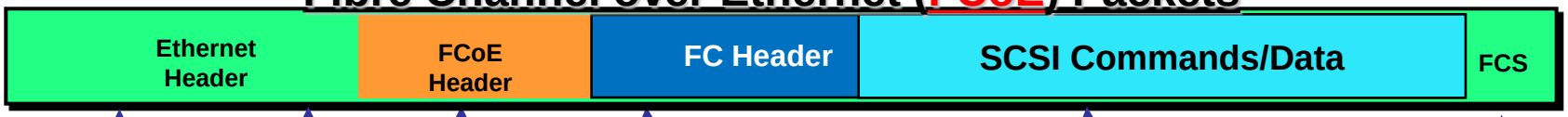
An DCB – Switch(es) may connect a number of VN2VN capable VN_Ports together
Or
A single Wire with VN2VN capable End Nodes can be interconnected

Architecture

FC Encapsulation Into Ethernet Frames
(2 FCoE Related Packet types)



Fibre Channel over Ethernet (FCoE) Packets



Ethertype "FCoE" (8906h)

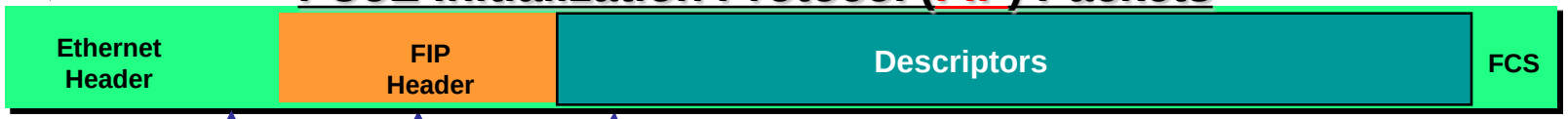
FC Imbedded Frames: Same as in Physical FC

Protocol control information: Version, SOF, EOF, etc.

Ethernet Header provides things needed for the physical network, including "Ethertype"

Frame Check Sequence (CRC)

FCoE Initialization Protocol (FIP) Packets



Ethertype "FIP" (8914h)

Discovery, Link establishment, maintenance & disconnect (Login/Logout, etc.) Parameters

Protocol control information: Version, Op-codes, etc.

FC's Encapsulation in Ethernet (FCoE)

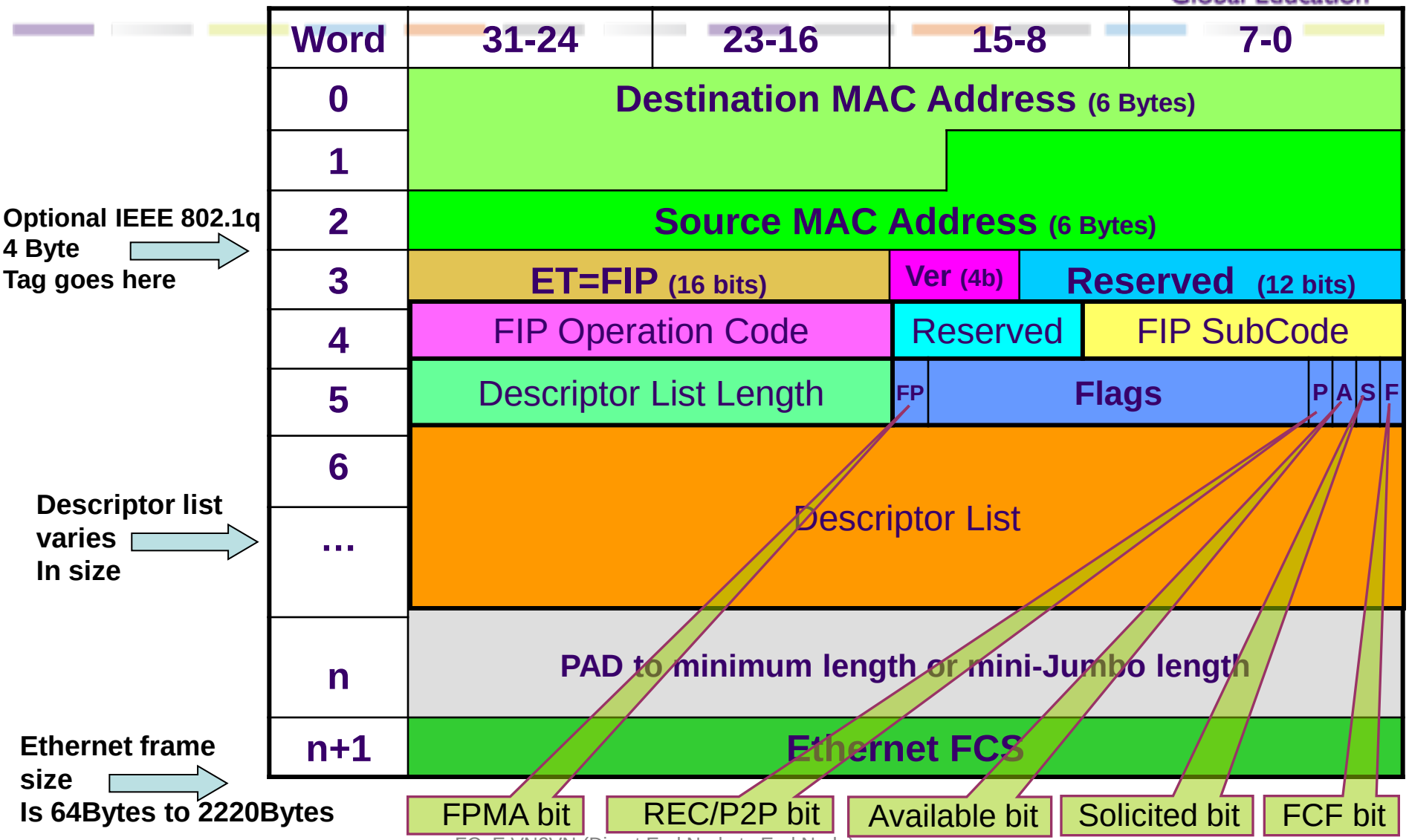
Optional IEEE 802.1q 4 Byte Tag goes here

This field varies In size

Ethernet frame Size is 64 Bytes to 2220Bytes

Word	31-24	23-16	15-8	7-0
0	Destination MAC Address (6 Bytes)			
1				
2	Source MAC Address (6 Bytes)			
3	ET=FCoE (16 bits)		Ver (4b)	Reserved (12 bits)
4	Reserved			
5	Reserved			
6	Reserved			SOF (8 bits)
7	Encapsulated FC Frame FC Frame = Minimum 28 Bytes (7 Words) → Maximum 2180 Bytes (545 Words) (including FC-CRC)			
…				
n				
n+1	EOF (8 bits)	Reserved		
n+2	Ethernet FCS			

FIP Operation Format



FIP Protocol for FCoE/VN2VN Networks

Discovery Phase

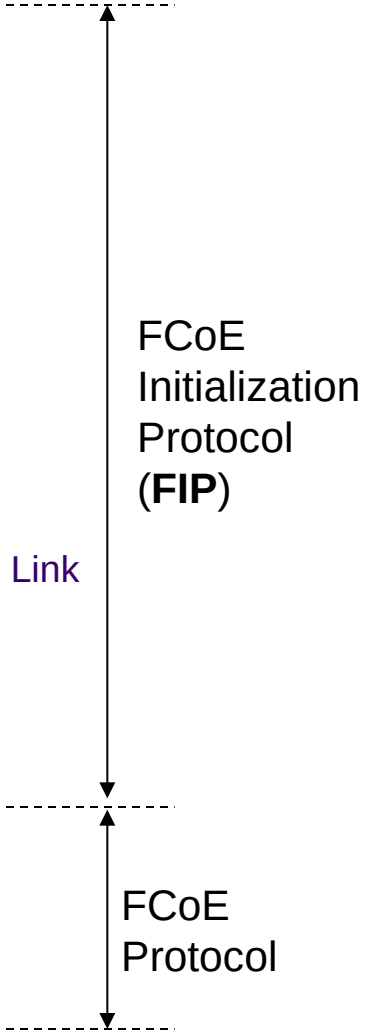
- FCoE (Base -- w/o VN2VN)
  - FCFs Discover each other, & form a Fabric
  - ENodes Discover FCFs & Potential VN_Port ← → VF_Port pairing
- FCoE VN2VN
  - VN2VN capable ENodes Discover each other

Login Phase

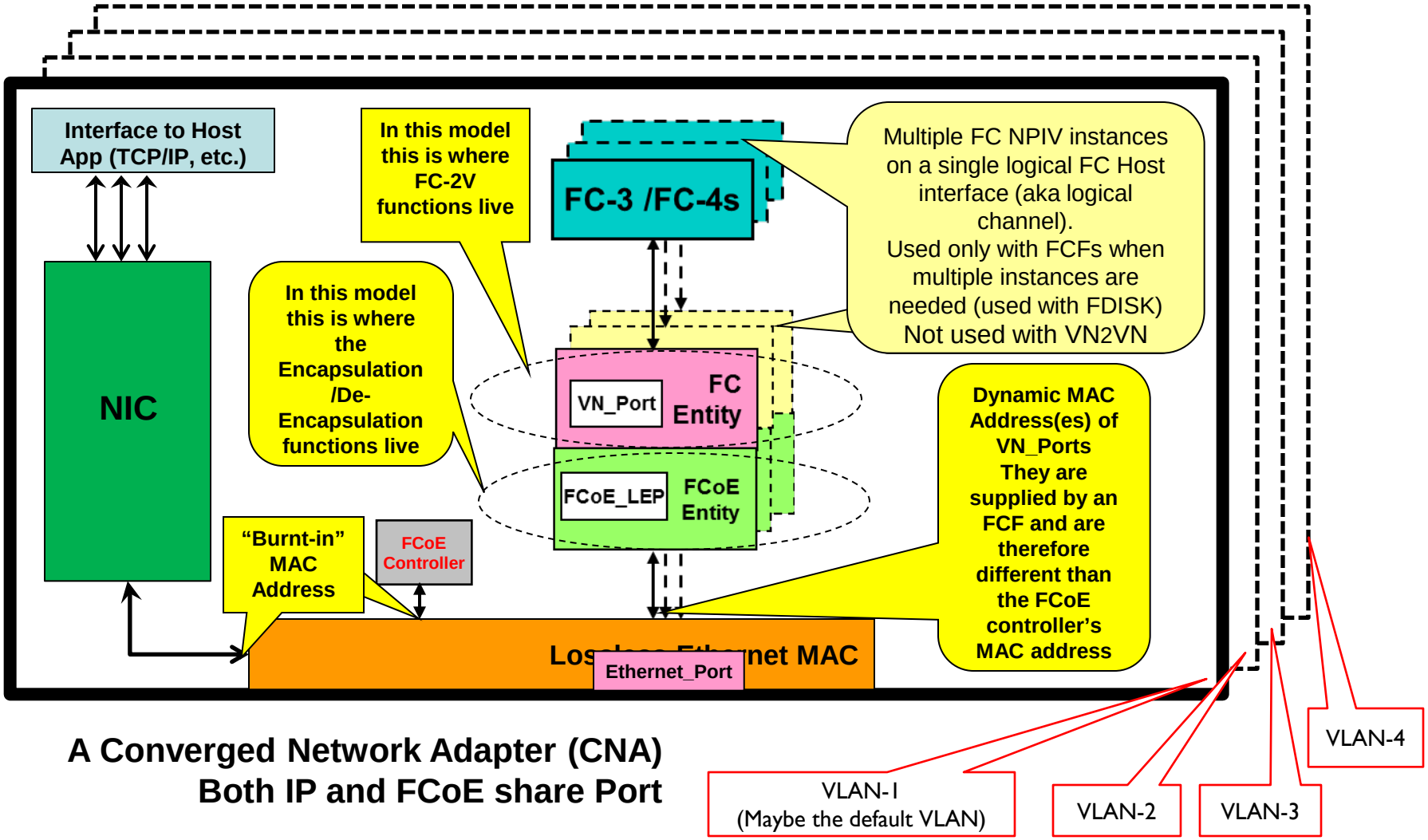
- FCoE (Base -- w/o VN2VN)
  - ENodes chose among discovered FCFs' Ports for Virtual Link connections
- FCoE VN2VN
  - VN2VN capable ENodes chose among discovered VN2VN Ports for Virtual Link connections
- Both Use: FLOGI, FLOGI ACC, LOGO, etc …

End-to-End path control & Data Transfer Phase

- PLOGI/PRLI
- All other FC protocol frames (FC4 ULPs. etc.)

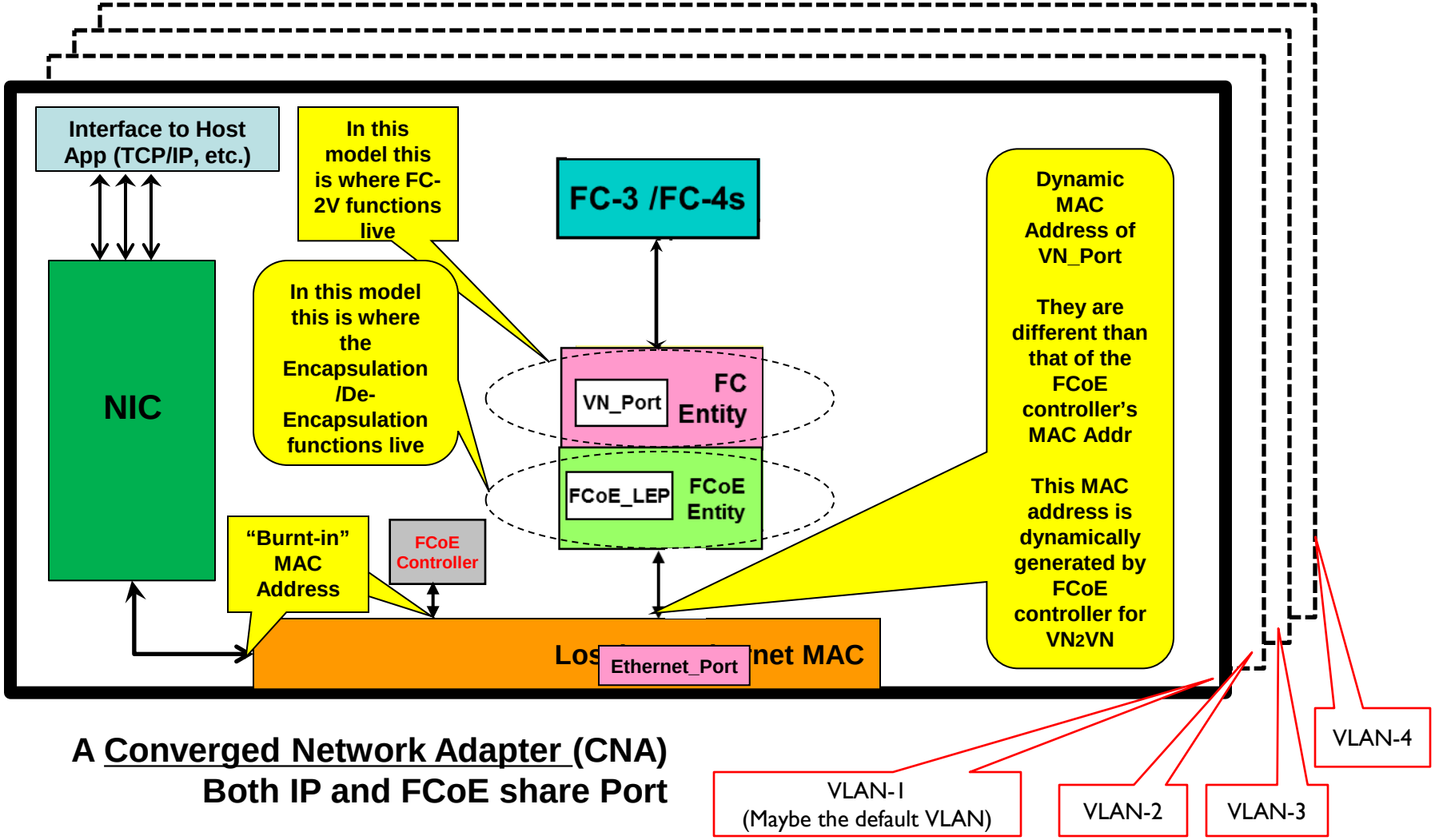


Model of an Basic FCoE ENode with on a single Ethernet Port
(with one Logical Channel)



A Converged Network Adapter (CNA)
Both IP and FCoE share Port

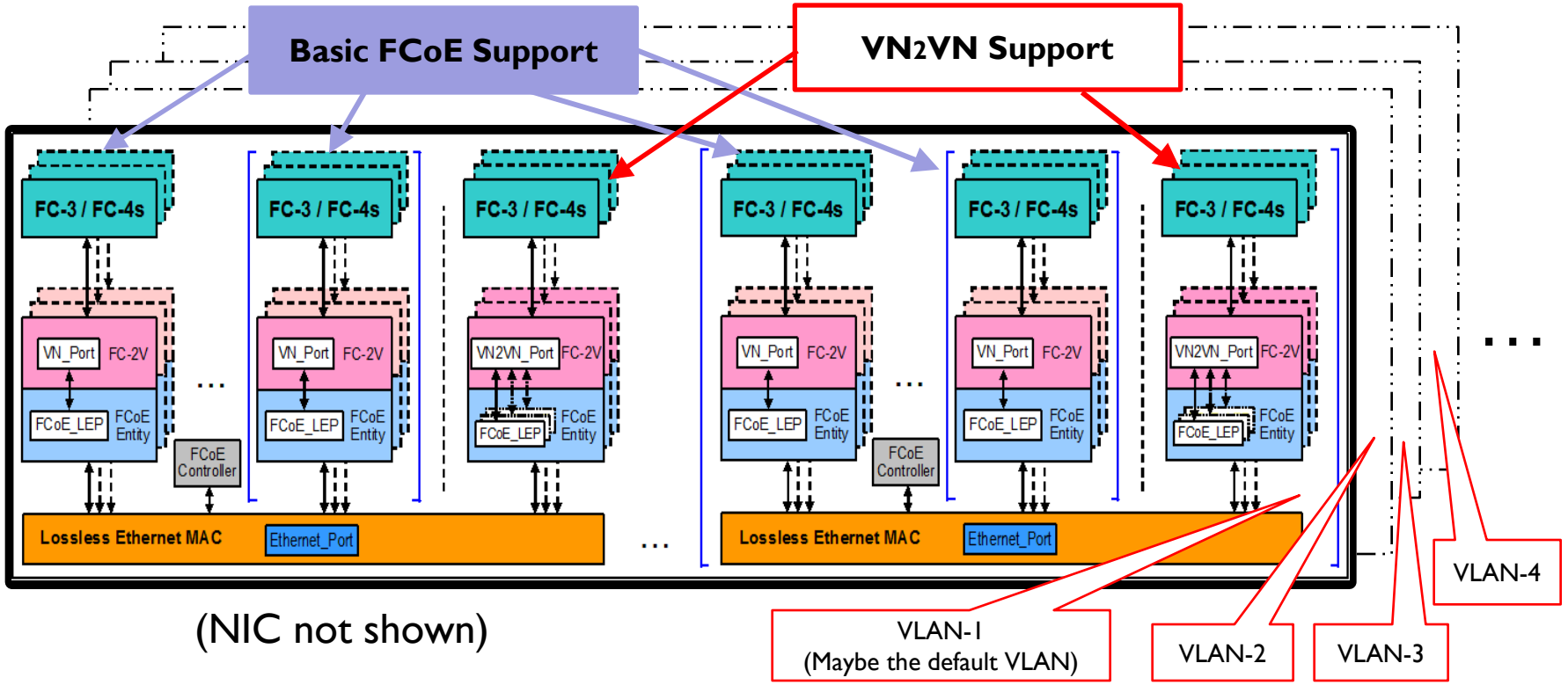
Model of an VN2VN ENode with a single Ethernet Port
(with one Logical Channel)



A Converged Network Adapter (CNA)
Both IP and FCoE share Port

ENode (HBA) Model with multiple Ethernet Ports with Both Basic FCoE and VN2VN support

(and with Multiple Logical Channels)

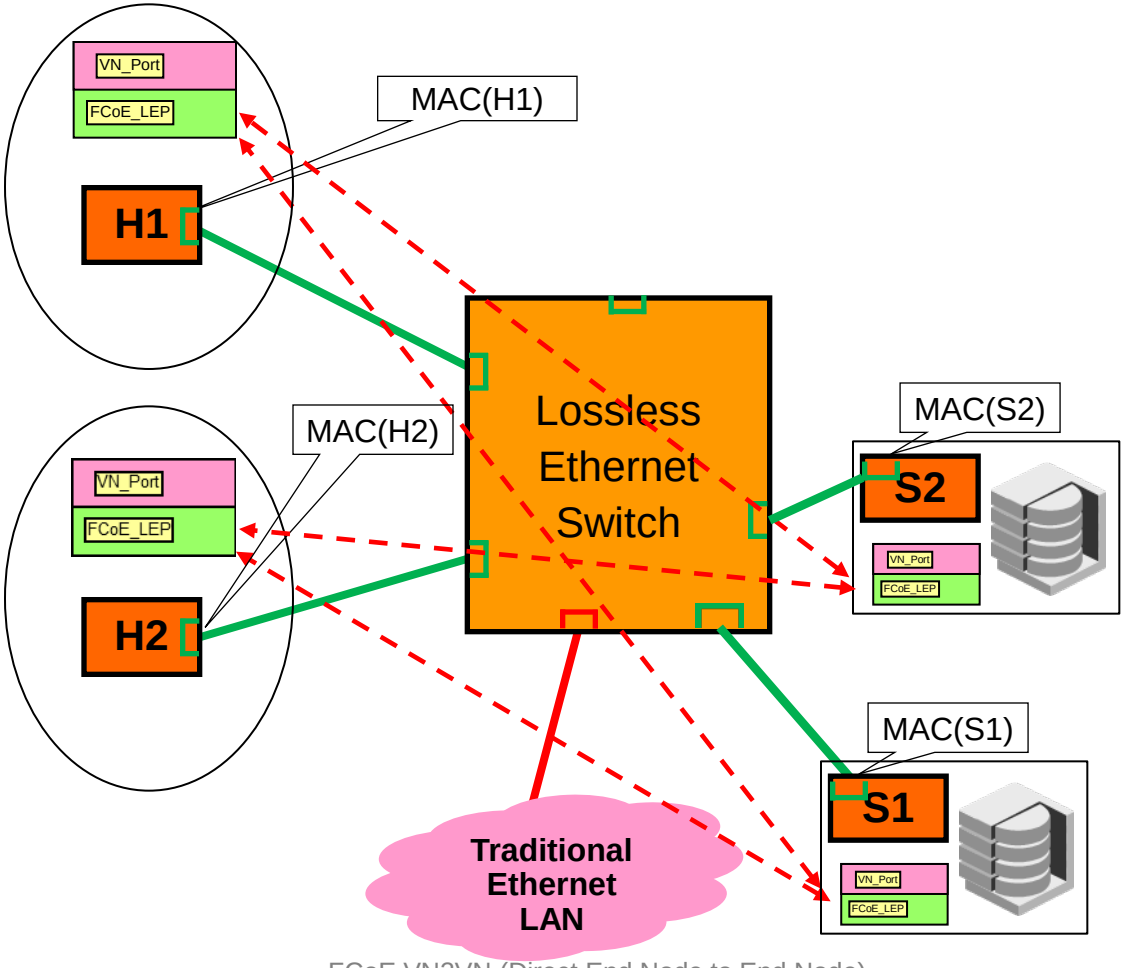


(NIC not shown)

Each ENode (HBA/**CNA**) may have one or multiple Physical Ethernet Ports
Each Physical Port may have multiple Logical VN_Ports

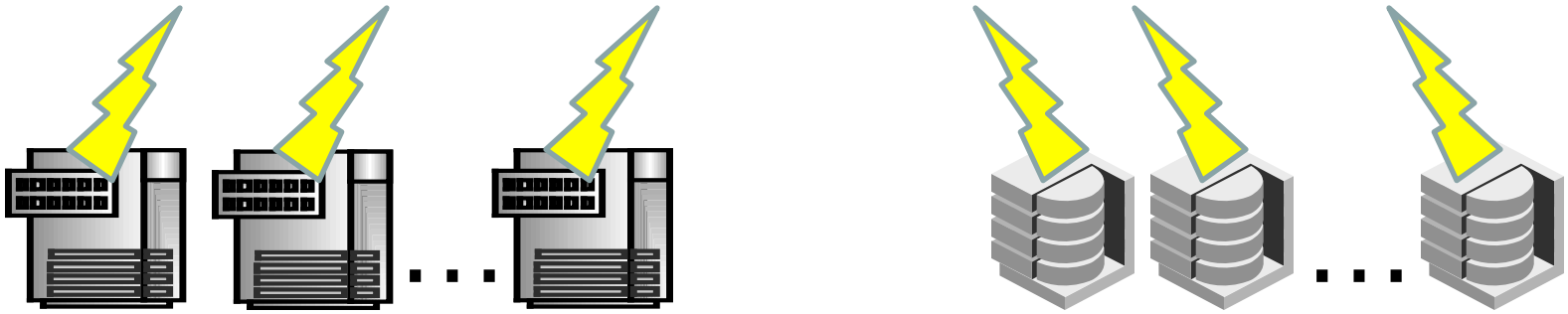
ENode to ENode Logical Links in VN2VN

An ENode must Locate Target with a Discovery protocol and then establish a Logical FC Link with an Target (VN_Port ← → VN_Port) before a Normal FCP frame flow



Discovery and Link Instantiation (FIP -- FCoE Initiation Protocol)

VN2VN MAC Address Creation and Claim



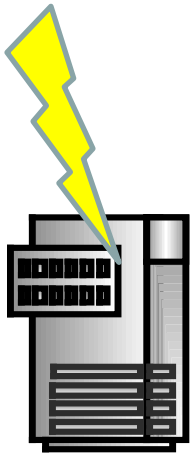
1. As each VN2VN enabled FCoE End-Node starts-up it will Randomly Generate its own:
   - FC LU-ID (N_Port_ID) and Ethernet MAC Address

2. Then Each VN2VN End-Node, on behalf of its VN_Port, Multicasts a PROBE with the Generated MAC Address & LU-ID
   - And listens for conflict responses

3. If Address/ID Conflict message is received, the process will repeat (at step1) until no Conflict messages are received

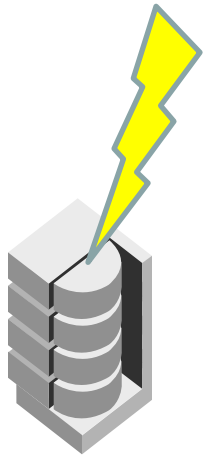
4. If no Conflicts are received, the End-Node instantiates the VN_Port and Multicasts its CLAIM to the MAC Address & LU-ID (N_Port_ID) and announces its "Capabilities" (FC-4 Features)

Discovery via Claim & Claim Responses



Neighbor Table

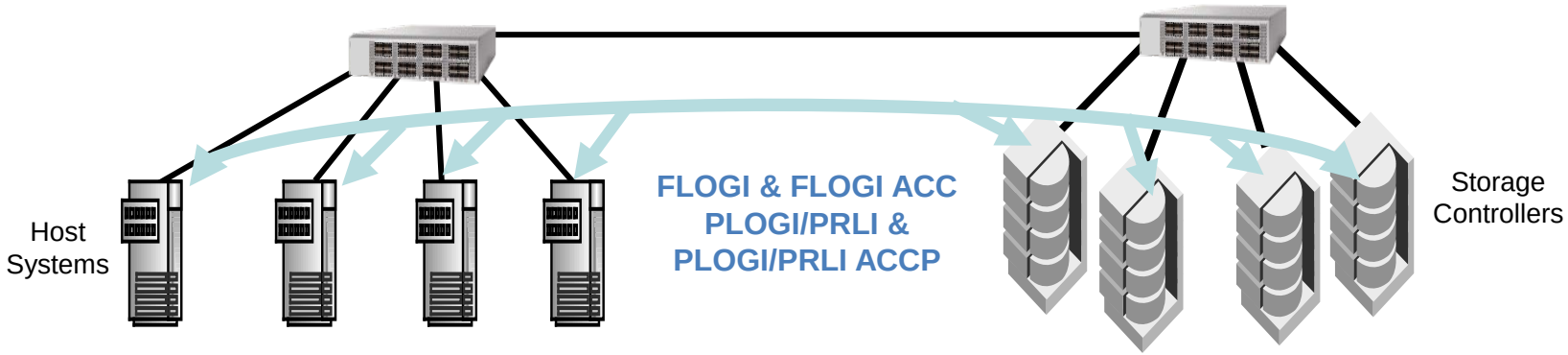
Name	MAC Address	LU-ID	Capabilities (FC-4 Features)



4. **Each VN2VN enabled FCoE End-Node receiving a CLAIM will respond with its own information & record the received CLAIMed information into a Neighbor Table – Including:**
   - **N_Port_Name, MAC Address & LU-ID and**
   - **Capabilities of the CLAIMing VN_Port (Initiator/Target, etc.)**

5. **Upon receiving CLAIM response messages, the CLAIMing End-Node will record the received CLAIM response information into its own Neighbor Table – Including:**
   - **N_Port_Name, MAC Address & LU-ID and**
   - **Capabilities of the responding VN_Port (Initiator/Target, etc.)**

Link Instantiation (for VN2VN)



Using the Neighbor Table

The Initiators (Hosts) chose their Targets (Disks) and Login

(FLOGI FIP frames set to the Targets)

The targets respond with Login accept

(FLOGI ACC FIP frames are sent back to Initiators)

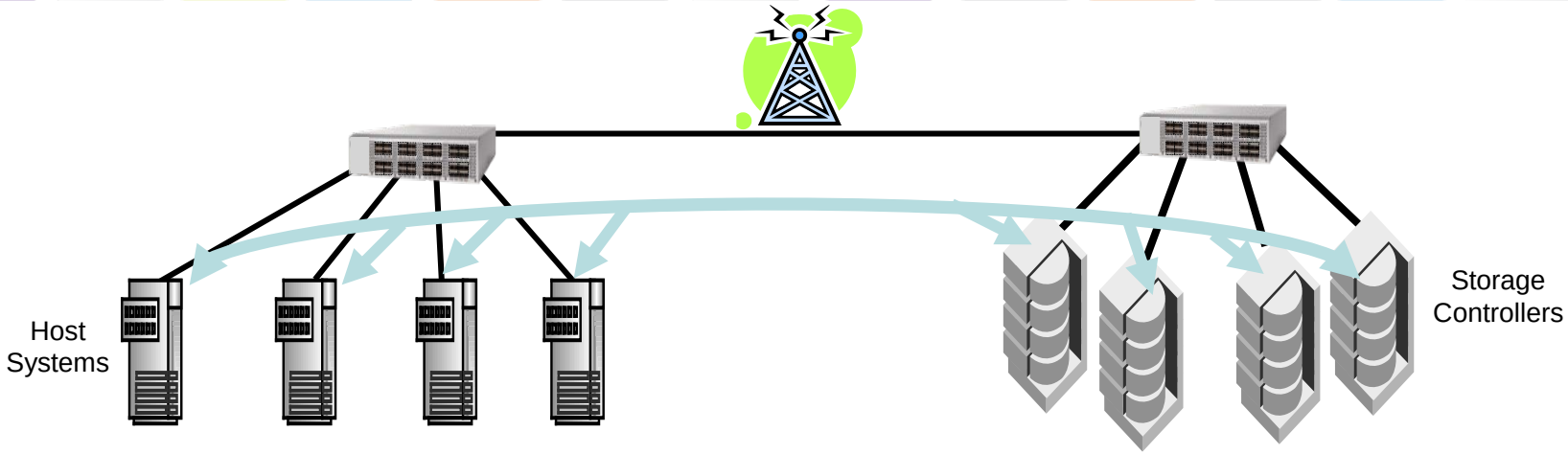
Then Process Logins FCoE Frames are exchanged

(PLOGI/PLOGI ACC & PRLI/PRLI ACC FCoE Frames are exchanged)

Thus Instantiating the VN2VN Logical Link

(other FCoE Frames can now flow)

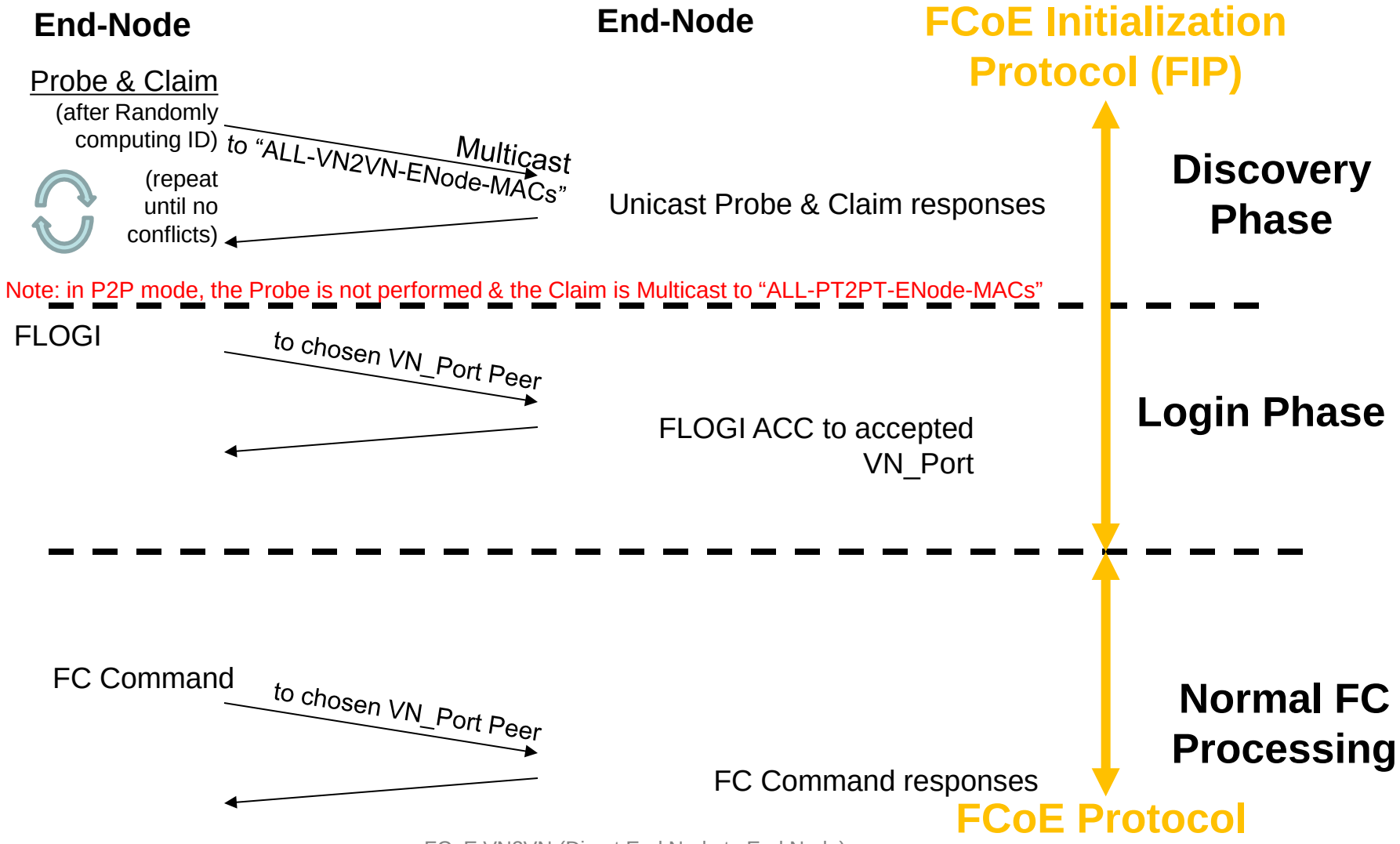
Beaconing (Keep Alive)



After Link Instantiation all VN_Port's IDs will be Periodically Beaconed (Multicast)

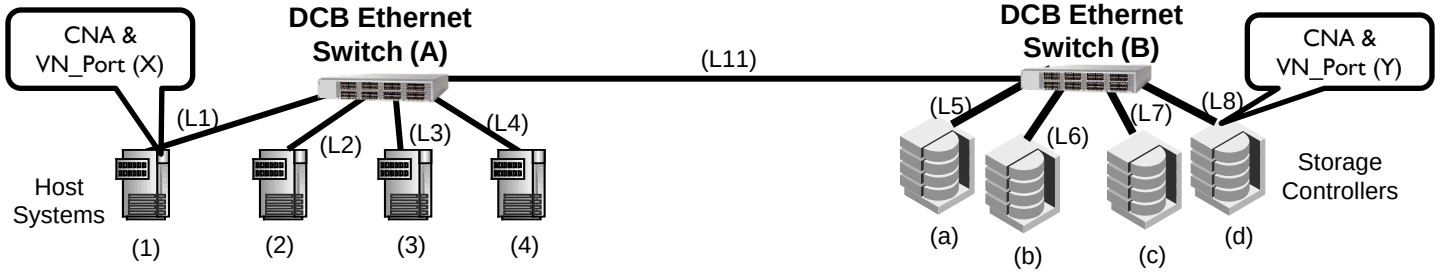
[Beaconing permits detection of link loss (via time-outs) & new or incorrect LAN joins]

VN2VN Initial Login Flow Ladder

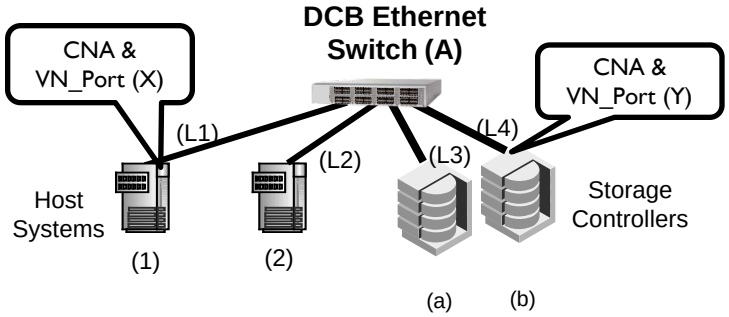


Topologies

Direct VN_Port to VN-Port (VN2VN)

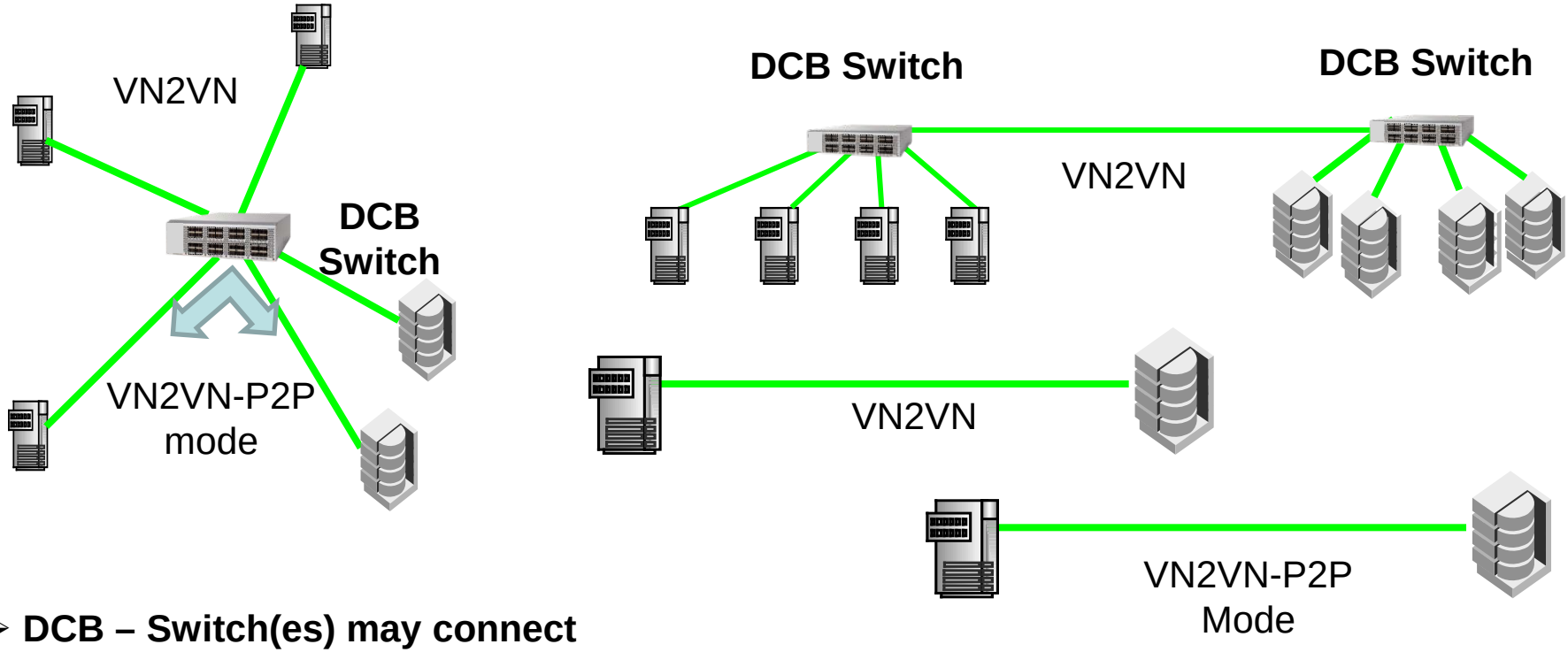


A CNA to CNA FCoE path between these Switch ports is now possible (even without an FCF) using Direct VN2VN mode



It is now possible to connect End-to-End as shown below

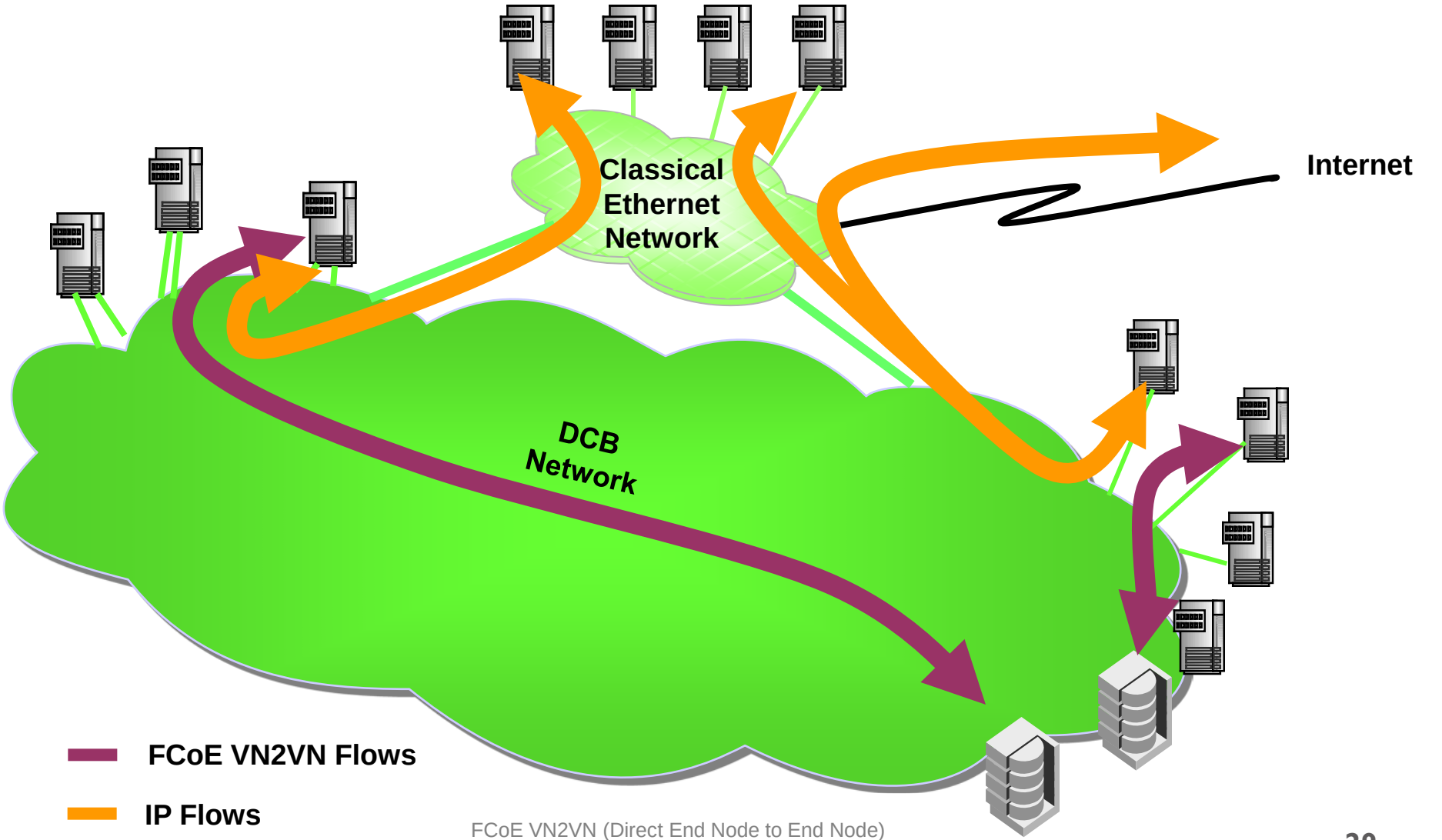
VN2VN Interconnect
Including P2P



- **DCB – Switch(es) may connect**
  - **A number of VN2VN capable VN_Ports together**
  - **Pairs of some configured VN2VN-P2P ENodes**
    (Requires physically/logically configuring the Switch)
- **A single Wire may connect**
  - **VN2VN ENodes (without P2P capability/configuration)**
  - **A pair of VN2VN-P2P ENodes**

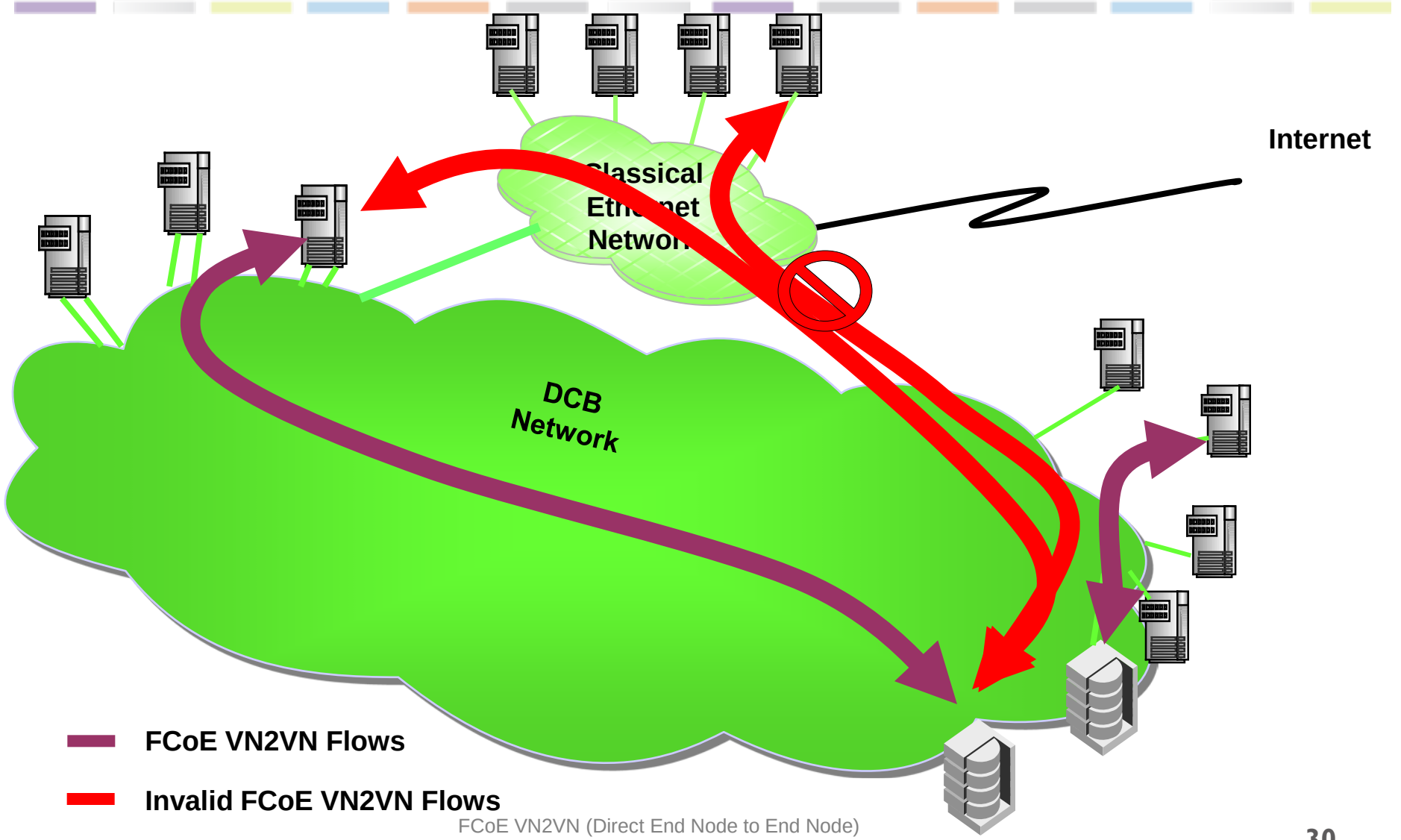
Scenarios

Scenario 1: FCoE & IP Flows



FCoE VN2VN (Direct End Node to End Node)

Scenario 2: FCoE Right & Wrong



Summary

FCoE Summary

- VN2VN is now a T11.3 (and INCITS) accepted Standard specification
- FCoE VN2VN is a simple, efficient mechanism for encapsulating Fibre Channel in Ethernet frames on a Lossless Ethernet type Network
  - Not a traditional Ethernet Interface or fabric
  - A New Network – A lossless Ethernet Network
  - Defined in the IEEE 802.1 standards working group (and called DCB)
  - FC protocols frames will just be inserted into these Ethernet frames
- Specification permits the installation to evolve from simple VN2VN into Full FCoE Fabrics (and even real FC Fabrics)
  - Can start small with simple Networks (even Point-to-Point)
    - Perhaps with all software Initiators/targets
  - May grow into larger FCoE fabrics in an evolutionally way
  - Full FCoE (Basic) Fabrics and VN2VN networks can co-exist as installations grow
  - When upgrading you can continue to use the same physical components
- Now FC protocols can span the small, medium, Enterprise and HPC networks
  - Only one protocol type (FC) is needed within the Data Center even if using different wire types
  - Different size companies can merge and their Data Center will easily merge also
  - Useful in HPC (High Performance Computing) since VN2VN is has the smallest switching overhead of any FC Fabric

Thank You!

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Attribution & Feedback

The SNIA Education Committee would like to thank the following individuals for their contributions to this Tutorial.

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Appendix

- FCoE Relation to ISO Layers

FCoE Relation to ISO Layers