7 FC-BB_E Structure and Concepts

7.1 Applicability

Clause 4 discussed the FC-BB_E reference model. This clause discusses the FC-BB_E functional models.

7.2 FC-BB_E overview

This clause discusses aspects of the FC-BB_E mapping, including initialization and procedures for the mapping of Fibre Channel frames over Ethernet.

Figure 25 shows how FC-BB_E maps the Fibre Channel levels and sublevels over IEEE 802.3 layers.

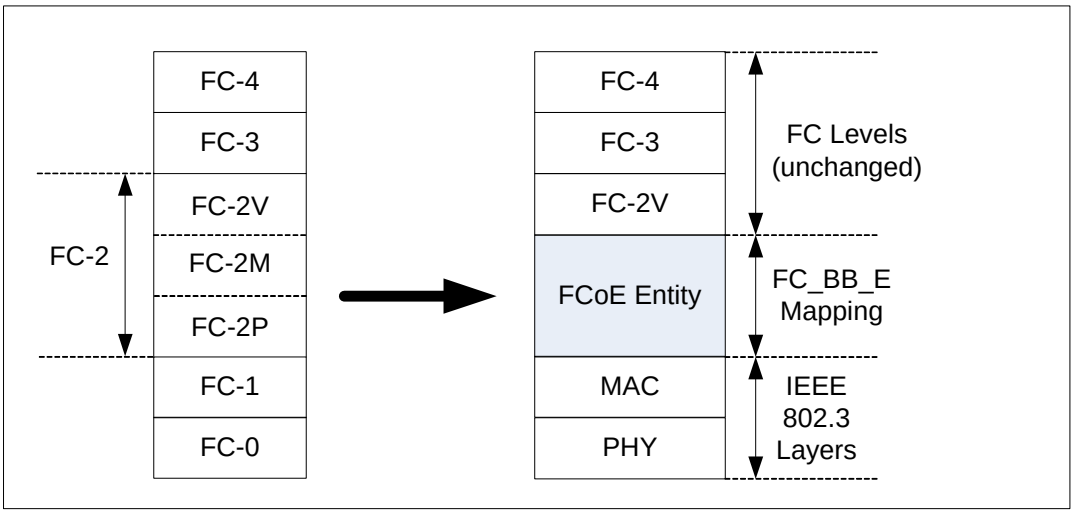

Figure 25 – FC-BB_E mapping

Figure 26 shows how the FC-BB_E mapping applies to FCoE Forwarders (FCF) and FCoE Nodes (ENodes).

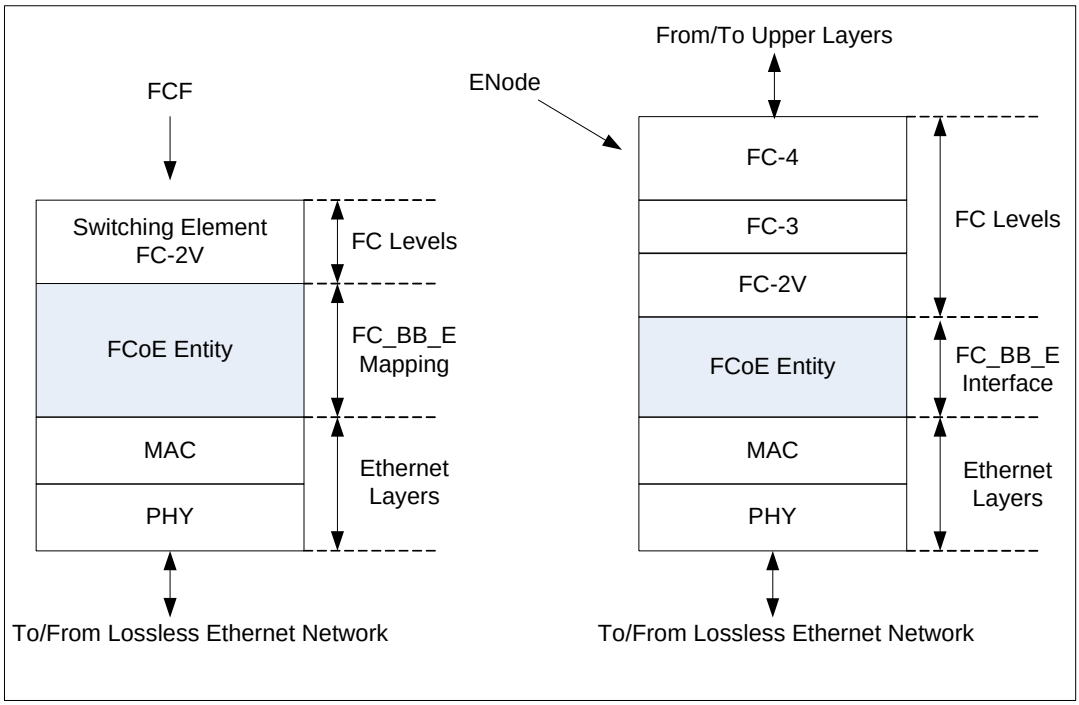

Figure 26 – FC-BB_E protocol levels and layers

FC-BB_E defines a direct mapping of Fibre Channel over Ethernet (FCoE). Although a generic Ethernet network may lose frames due to congestion, a proper implementation of appropriate Ethernet extensions (e.g., the PAUSE mechanism defined in IEEE 802.3-2008) allows a full duplex Ethernet link to provide a lossless behavior equivalent to the one provided by the buffer-to-buffer credit mechanism (see FC-FS-3). The protocol mapping defined by FC-BB_E is referred to as Fibre Channel over Ethernet (FCoE) and shall use an underlying Ethernet layer (i.e., composed only of full duplex links and providing a lossless behavior when carrying FCoE frames (see 4.4.4)). The Lossless Ethernet layer provides sequential delivery of FCoE frames.

In native Fibre Channel, Fibre Channel Nodes (see FC-FS-3) and Switches (see FC-SW-5) communicate through FC_Ports. Fibre Channel links connect PN_Ports to PF_Ports and PE_Ports to PE_Ports.

In Fibre Channel over Ethernet, FCoE Nodes (ENodes) and FCoE Forwarders (FCFs) communicate through Ethernet ports over a Lossless Ethernet network. FCoE Virtual Links replace the physical Fibre Channel links by encapsulating FC frames in Ethernet frames. FCoE supports VE_Port to VE_Port Virtual Links and VN_Port to VF_Port Virtual Links. A VE_Port to VE_Port Virtual Link is identified by the pair of MAC addresses of the two link end-points. A VN_Port to VF_Port Virtual Link is identified in general by the pair of MAC addresses of the two link end-points and by the N_Port_ID assigned to the VN_Port. When VN_Port MAC addresses are unique per VN_Port (e.g., when FPMAs are used (see 7.6)), the pair of MAC addresses of the two link end-points is enough to identify a VN_Port to VF_Port Virtual Link.

Figure 27 shows an example FCoE VN_Port to VF_Port network configuration.

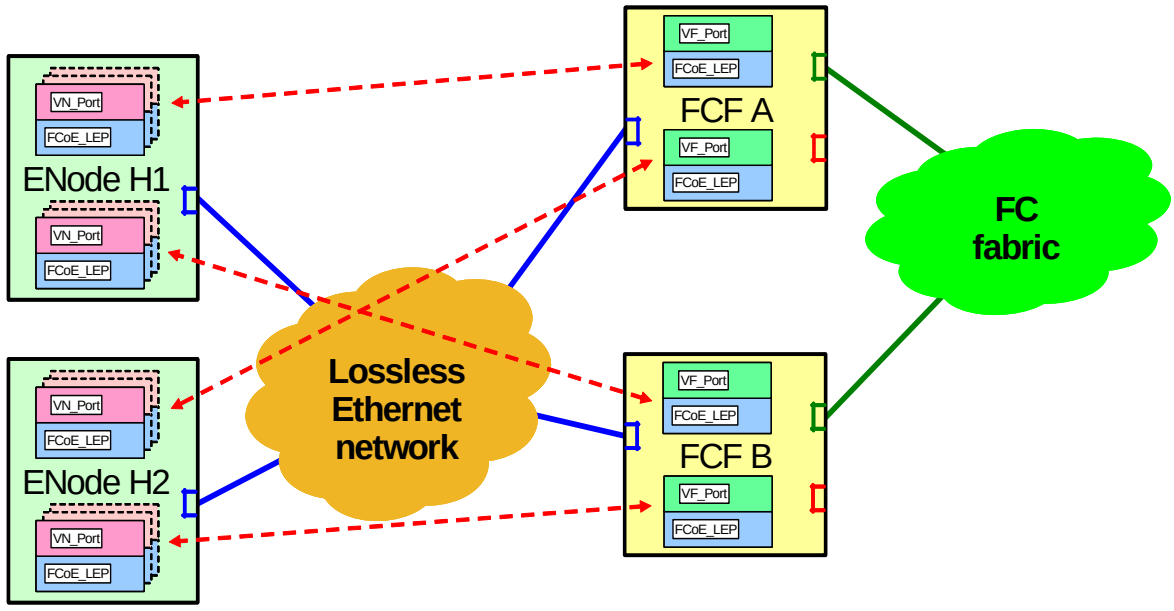

Figure 27 – FCoE VN_Port to VF_Port network configuration example

Each of the two ENodes H1 and H2 depicted in figure 27 has a single physical Ethernet connection to the Lossless Ethernet network. Each of the two FCFs, FCF A and B, has a single physical Ethernet connection to the Lossless Ethernet network. Each ENode may instantiate multiple VN_Ports, connected to VF_Ports instantiated by the FCFs through FCoE Virtual Links. The dotted lines in figure 27 depict possible VN_Port to VF_Port Virtual Links. In this case, a Lossless Ethernet network is reduced by FCoE to a set of point-to-point VN_Port to VF_Port Virtual Links where the VN_Port to VF_Port Fibre Channel protocols are able to operate.

Figure 28 shows an FCoE VE_Port to VE_Port network configuration.

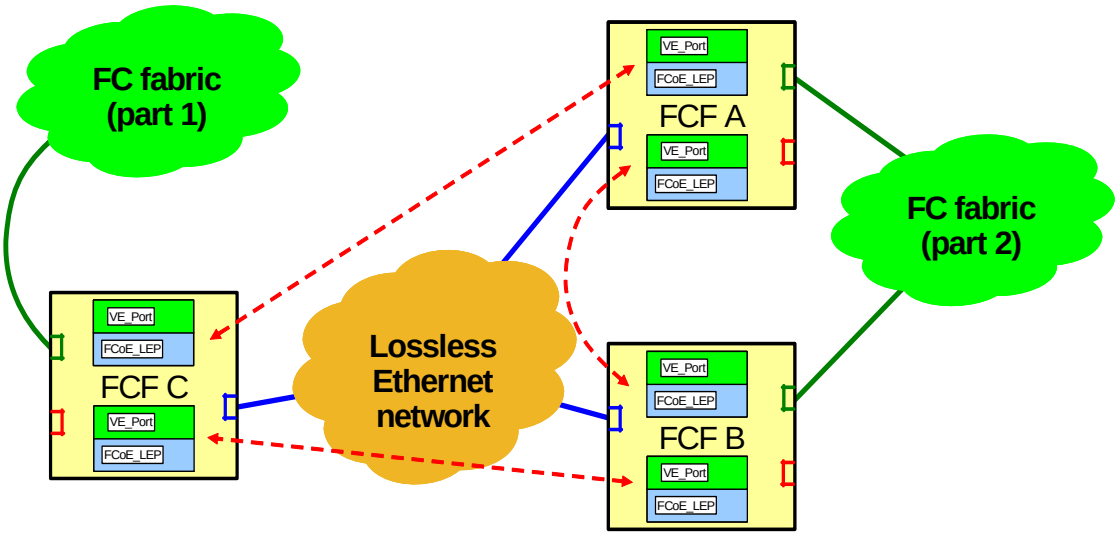

Figure 28 – FCoE VE_Port to VE_Port network configuration example

Each of the three FCFs A, B, and C depicted in figure 28 has a single physical Ethernet connection to the Lossless Ethernet network. Each FCF may instantiate multiple VE_Ports, connected to other VE_Ports through FCoE Virtual Links. The dotted lines in figure 28 depict possible VE_Port to VE_Port Virtual Links. In this case, a Lossless Ethernet network is reduced by FCoE to a set of point-to-point VE_Port to VE_Port Virtual Links where the VE_Port to VE_Port Fibre Channel protocols are able to operate.

As shown in figure 27 and figure 28, Fibre Channel over Ethernet enables some additional features in respect to native Fibre Channel:

a) an ENode may establish VN_Port to VF_Port Virtual Links (i.e., perform Fabric Login) with multiple FCFs through a single Lossless Ethernet MAC;
b) an FCF may establish VN_Port to VF_Port Virtual Links (i.e., accept Fabric Login) with multiple ENodes through a single Lossless Ethernet MAC; and
c) an FCF may establish VE_Port to VE_Port Virtual Links with multiple other FCFs through a single Lossless Ethernet MAC.

7.3 ENode functional model

Figure 29 shows the functional model of an ENode, where the bracketed functional components are optional. An ENode is functionally composed of at least one Lossless Ethernet MAC (i.e., the ENode MAC), and an FCoE Controller function for each ENode MAC.

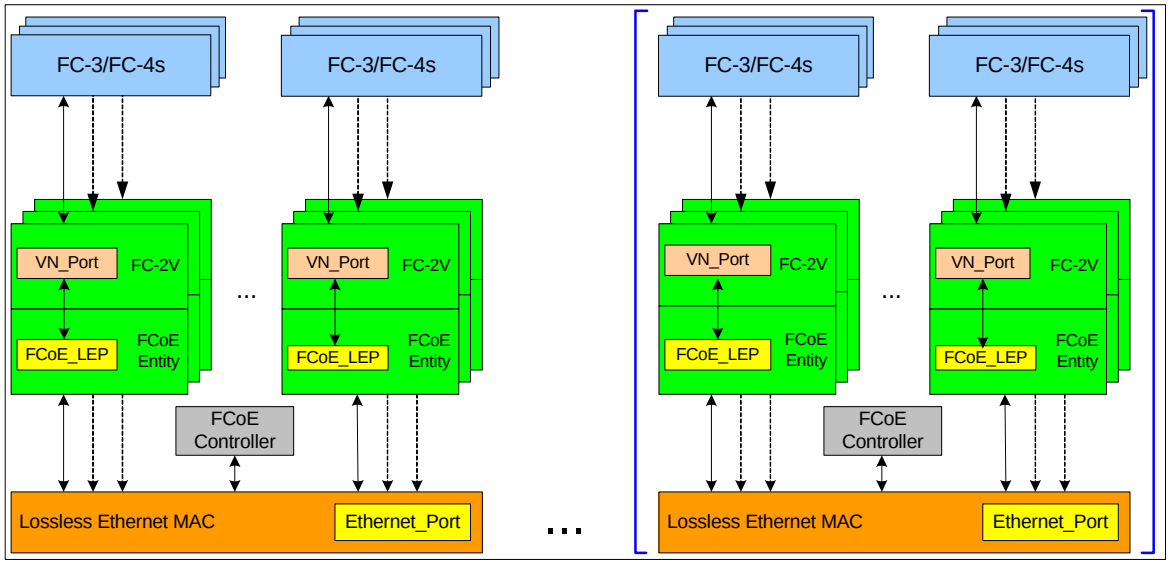

Figure 29 – ENode functional model

The FCoE Controller associated with an ENode MAC shall support the instantiation of VN_Port/FCoE_LEP pairs.

The FCoE Controller is the functional entity that performs the FCoE Initialization Protocol (FIP) and instantiates or de-instantiates VN_Port/FCoE_LEP pairs as needed.

For an ENode's MAC, the FCoE Controller:

a) optionally initiates the FIP VLAN discovery protocol to discover FCoE VLANs;

b) should initiate the FIP discovery protocol in order to discover VF_Port capable FCF-MACs connected to the same Lossless Ethernet network;
c) initiates FIP FLOGI Exchanges and instantiates a VN_Port/FCoE_LEP pair on successful completion of each FIP FLOGI Exchange with a VF_Port capable FCF-MAC;
d) optionally initiates FIP NPIV FDISC Exchanges and instantiates a VN_Port/FCoE_LEP pair on successful completion of each FIP NPIV FDISC Exchange with a VF_Port capable FCF-MAC;
e) de-instantiates a VN_Port/FCoE_LEP pair when that VN_Port is logged out from the Fabric;
f) initiates FIP LOGO Exchanges when explicit Fabric logout is needed;
g) de-instantiates the indicated VN_Port/FCoE_LEP pairs on receiving FIP Clear Virtual Link requests;
h) transmits periodic FIP Keep Alive frames on behalf of the ENode MAC every FKA_ADV_PERIOD, unless the D bit is set to one in received Discovery Advertisements (see 7.8.5.2);
i) monitors the status of instantiated VN_Port/FCoE_LEP pairs and transmits periodic FIP Keep Alive frames on their behalf every FKA_VN_PERIOD, unless the D bit is set to one in received Discovery Advertisements (see 7.8.5.2); and
j) monitors the status of VF_Ports to which the instantiated VN_Port/FCoE_LEP pairs are logged in by maintaining timers and verifying periodic FIP Discovery Advertisements are received within every FKA_ADV_PERIOD, unless the D bit is set to one in received Discovery Advertisements (see 7.8.5.2).

The FCoE Controller of an ENode MAC may perform FIP FLOGIs and FIP NPIV FDISCs with multiple VF_Port capable FCF-MACs. VN_Ports instantiated by the FCoE Controller of an ENode MAC on successful completion of FIP NPIV FDISC Exchanges with a VF_Port capable FCF-MAC are all associated with the same VF_Port, instantiated by the FCoE Controller of that VF_Port capable FCF-MAC on successful completion of a FIP FLOGI Exchange. In figure 29, each stack of VN_Port/FCoE_LEP pairs represents an association with a different VF_Port capable FCF-MAC.

The FCoE_LEP is the functional entity performing the encapsulation of FC frames into FCoE frames in transmission and the decapsulation of FCoE frames into FC frames in reception. An FCoE_LEP operates according to the MAC address of the local link end-point and the MAC address of the remote link end-point. When encapsulating FC frames into FCoE frames, the MAC address of the local link end-point shall be used as source address and the MAC address of the remote link end-point shall be used as destination address of the generated FCoE frame. When decapsulating FC frames from FCoE frames, the FCoE_LEP shall verify that the destination address of the received FCoE frame is equal to the MAC address of the local link end-point and shall verify that the source address of the received FCoE frame is equal to the MAC address of the remote link end-point. If either check fails the FCoE frame shall be discarded.

For an FCoE_LEP of an ENode MAC, the MAC address of the local link end-point is the MAC address associated with its VN_Port and the remote link end-point address is the FCF-MAC address associated with the remote VF_Port. The VN_Port may use an FPMA or an SPMA as its MAC address.

A VN_Port is an instance of the FC-2V sublevel of Fibre Channel that operates as an N_Port (see FC-FS-3) and is dynamically instantiated together with its FCoE_LEP on successful completion of a FIP FLOGI Exchange or a FIP NPIV FDISC Exchange. A VN_Port receives FC frames from the upper FC levels and sends them to its FCoE_LEP for encapsulation and transmission over the Lossless Ethernet network. In a similar way, a VN_Port sends FC frames received from its FCoE_LEP to the upper FC levels. A VN_Port may support one or more FC-4s. A VN_Port is uniquely identified by an N_Port_Name Name_Identifier and is addressed by the address identifier the Fabric assigned to it. The VN_Port behavior shall be as specified in FC-LS-2 and FC-FS-3, with the exception that a VN_Port is instantiated on successful completion of a FIP FLOGI Exchange or a FIP NPIV FDISC Exchange, ignoring the buffer-to-buffer flow control parameters, rather than on

completion of a native FLOGI or NPIV FDISC Exchange. When receiving FC frames from its FCoE_LEP, a VN_Port shall verify that the D_ID of the received FC frame is equal to its address identifier. If the check fails the FC frame shall be discarded.

NOTE 13 – The receive checks performed by the VN_Port/FCoE_LEP pair verify that the correct MAC destination address, MAC source address, and D_ID are present in a received FCoE frame (see D.5).

7.4 FCF functional model

Figure 30 shows the functional model of an FCF, where the bracketed functional components are optional. An FCF is functionally composed of a Fibre Channel Switching Element (see FC-SW-5) with at least one Lossless Ethernet MAC (FCF-MAC). Each FCF-MAC shall be coupled with an FCoE Controller function. Each FCF-MAC may be coupled with a Lossless Ethernet bridging element. The Fibre Channel Switching Element may be coupled with a Fibre Channel Fabric interface, providing native E_Port and F_Port connectivity. An FCF forwards FCoE frames addressed to one of its FCF-MACs based on the D_ID of the encapsulated FC frames.

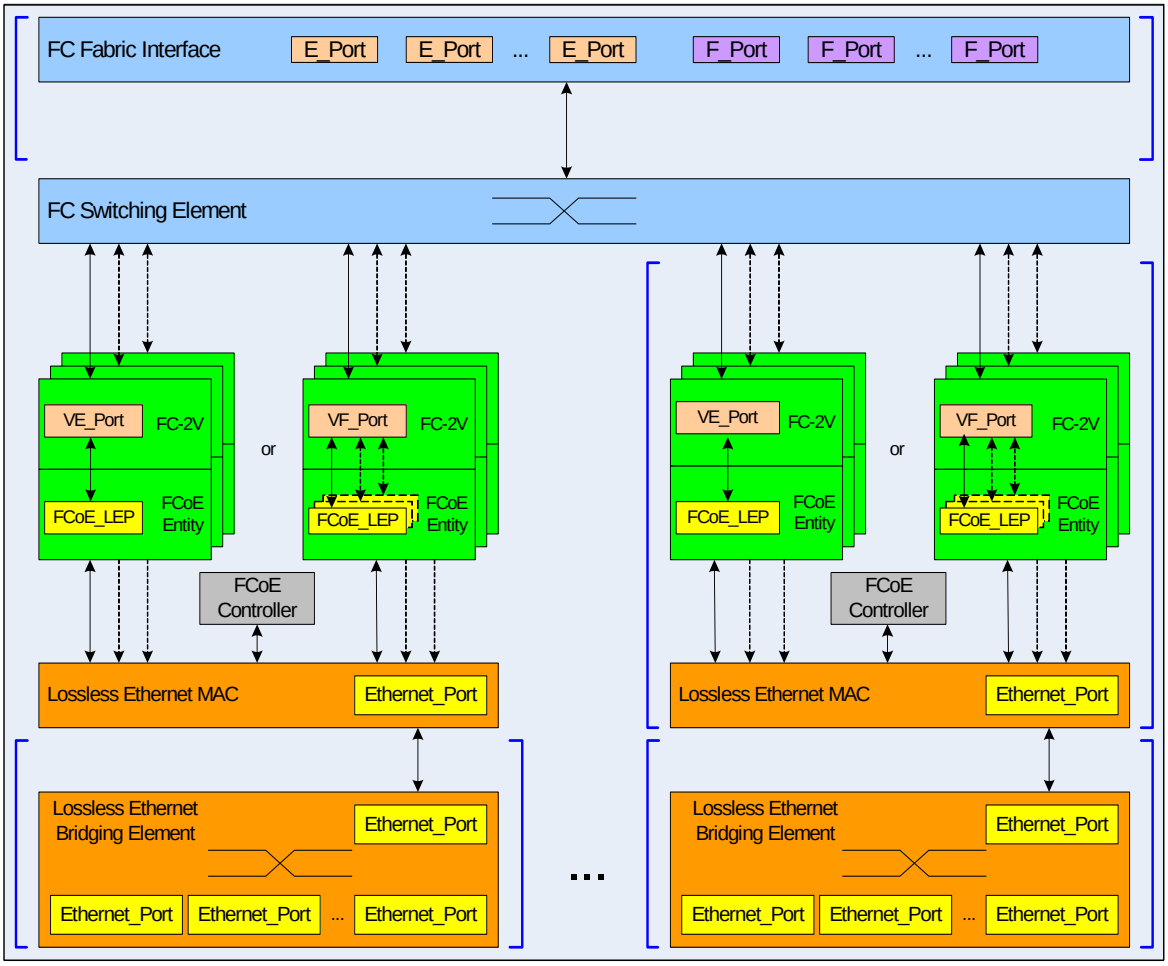

Figure 30 – FCF functional model

NOTE 14 – Other combinations of Lossless Ethernet bridging elements and Lossless Ethernet MACs connections are allowed.

When an FCF includes Lossless Ethernet bridging elements, an FCF-MAC address may be used by multiple Ethernet ports of the FCF.

The FCoE Controller associated with an FCF-MAC shall support the instantiation of VE_Port/FCoE_LEP pairs or VF_Port/FCoE_LEP pairs. An FCF-MAC supporting the instantiation of VE_Port/FCoE_LEP pairs is referred to as a VE_Port capable FCF-MAC. An FCF-MAC supporting the instantiation of VF_Port/FCoE_LEP pairs is referred to as a VF_Port capable FCF-MAC. Support for both VE_Port/FCoE_LEP pairs and VF_Port/FCoE_LEP pairs on the same FCF-MAC is prohibited.

MAC addresses used by FCFs for FCF-MACs shall be different than MAC addresses used by ENodes for ENode MACs.

The FCoE Controller is the functional entity that performs the FCoE Initialization Protocol (FIP) and instantiates or de-instantiates VE_Port/FCoE_LEP pairs or VF_Port/FCoE_LEP pairs as needed.

For a VE_Port capable FCF-MAC, the FCoE Controller:

a) optionally performs the FIP VLAN discovery protocol to discover FCoE VLANs;
b) discovers other VE_Port capable FCF-MACs connected to the same Lossless Ethernet network using the FIP discovery protocol;
c) instantiates a VE_Port/FCoE_LEP pair on successful completion of each FIP ELP Exchange with a remote FCF-MAC;
d) de-instantiates a VE_Port/FCoE_LEP pair on receiving a FIP Clear Virtual Link request;
e) monitors the status of the instantiated VE_Port/FCoE_LEP pairs;
f) initiates FIP Clear Virtual Link requests as needed to terminate Virtual Links to other VE_Ports;
g) transmits periodic FIP Discovery Advertisements to the All-FCF-MACs address every FKA_ADV_PERIOD; and
h) monitors the status of remote VE_Ports by maintaining timers and verifying that periodic FIP Discovery Advertisements are received within every FKA_ADV_PERIOD.

For a VF_Port capable FCF-MAC, the FCoE Controller:

a) participates in the FIP VLAN discovery protocol initiated by an ENode MAC;
b) participates in the FIP discovery protocol initiated by an ENode MAC;
c) instantiates a VF_Port/FCoE_LEP pair on successful completion of each FIP FLOGI Exchange initiated by an ENode MAC;
d) instantiates an additional FCoE_LEP on successful completion of each FIP NPIV FDISC Exchange initiated by an already logged in ENode MAC. The resulting VF_Port/FCoE_LEP pair shares the VF_Port with the VF_Port/FCoE_LEP pair instantiated on successful completion of the FIP FLOGI Exchange;
e) when a VN_Port is logged out, de-instantiates the FCoE_LEP associated to that VN_Port and de-instantiates the corresponding VF_Port if that FCoE_LEP was the only one associated with that VF_Port;
f) initiates FIP Clear Virtual Link requests as needed to terminate Virtual Links to VN_Ports;
g) monitors the status of the instantiated VF_Port/FCoE_LEP pairs;
h) transmits periodic FIP Discovery Advertisements to the All-ENode-MACs address every FKA_ADV_PERIOD;
i) monitors the status of the logged in ENode MACs by verifying that periodic FIP Keep Alive frames are received within FKA_ADV_PERIOD, unless the D bit is set to one in received Discovery Advertisements (see 7.8.5.2); and
j) monitors the status of the logged in VN_Ports by maintaining timers and verifying that periodic FIP Keep Alive frames are received within FKA_VN_PERIOD, unless the D bit is set to one in received Discovery Advertisements (see 7.8.5.2).

The FCoE Controller of an ENode MAC may perform FIP FLOGIs and FIP NPIV FDISCs with multiple VF_Port capable FCF-MACs. VN_Ports instantiated by the FCoE Controller of an ENode MAC on successful completion of FIP NPIV FDISC Exchanges with a VF_Port capable FCF-MAC are all associated with the same VF_Port, instantiated by the FCoE Controller of that VF_Port capable FCF-MAC on successful completion of a FIP FLOGI Exchange.

The FCoE_LEP is the functional entity performing the encapsulation of FC frames into FCoE frames in transmission and the decapsulation of FCoE frames into FC frames in reception. An FCoE_LEP operates according to the MAC address of the local link end-point and the MAC address of the remote link end-point. When encapsulating FC frames into FCoE frames, the MAC address of the local link end-point shall be used as source address and the MAC address of the remote link end-point shall be used as destination address of the generated FCoE frame. When decapsulating FC frames from FCoE frames, the FCoE_LEP shall verify that the destination address of the received FCoE frame is equal to the MAC address of the local link end-point and shall verify that the source address of the received FCoE frame is equal to the MAC address of the remote link end-point. If either check fails the FCoE frame shall be discarded.

For a VE_Port capable FCF-MAC, the MAC address of the local link end-point is the FCF-MAC address and the MAC address of the remote link end-point is the MAC address of the remote FCF-MAC with which a FIP ELP Exchange has been successfully completed.

For a VF_Port capable FCF-MAC, the MAC address of the local link end-point is the FCF-MAC address and the MAC address of the remote link end-point is the MAC address associated with the remote logged in VN_Port. The remote VN_Port may use an FPMA or an SPMA as its MAC address.

A VE_Port is an instance of the FC-2V sublevel of Fibre Channel that operates as an E_Port in accordance with FC-SW-5 and is dynamically instantiated together with its FCoE_LEP on successful completion of a FIP ELP Exchange. A VE_Port receives FC frames from the FC Switching Element and sends them to its FCoE_LEP for encapsulation and transmission over the Lossless Ethernet network. In a similar way, a VE_Port sends FC frames received from its FCoE_LEP to the FC Switching element. A VE_Port is uniquely identified by an E_Port_Name Name_Identifier and is addressed by the Fabric Controller address identifier (i.e., FFFFFDh). The VE_Port behavior shall be as specified in FC-SW-5, with the exception that a VE_Port is instantiated on successful completion of a FIP ELP Exchange, ignoring the buffer-to-buffer flow control parameters, rather than on completion of a native ELP Exchange.

A VF_Port is an instance of the FC-2V sublevel of Fibre Channel that operates as an F_Port in accordance with FC-SW-5 and is dynamically instantiated together with its FCoE_LEP on successful completion of a FIP FLOGI Exchange. A VF_Port receives FC frames from the FC Switching Element and sends them to the proper FCoE_LEP for encapsulation and transmission over the Lossless Ethernet network. In a similar way, a VF_Port sends FC frames received from one of its FCoE_LEPs to the Fibre Channel Switching element. A VF_Port is uniquely identified by an F_Port_Name Name_Identifier and is addressed by the F_Port Controller address identifier (i.e., FFFFFEh). The VF_Port behavior shall be as specified in FC-LS-2 and FC-FS-3, with the exception that a VF_Port is instantiated on successful completion of a FIP FLOGI Exchange, ignoring the buffer-to-buffer flow control parameters, rather than on completion of a native FLOGI Exchange. When receiving FC frames from one of its FCoE_LEPs, a VF_Port shall verify that the S_ID of the received FC frame is equal to the address identifier of the VN_Port associated to that FCoE_LEP. If the check fails the FC frame shall be discarded.

NOTE 15 – The receive checks performed by the VF_Port/FCoE_LEP pair verify that the correct MAC destination address, MAC source address, and D_ID are present in a received FCoE frame (see D.5).

The Fibre Channel Switching Element is the functional entity performing Fibre Channel switching among E_Ports, F_Ports, VE_Ports, and VF_Ports. A Fibre Channel Switching Element is uniquely identified by a Switch_Name Name_Identifier. The behavior of the Fibre Channel Switching Element shall be as specified in FC-SW-5.

7.5 FCoE Virtual Links

Figure 31 shows how the model defined in 7.4 models VE_Port to VE_Port Virtual Links.

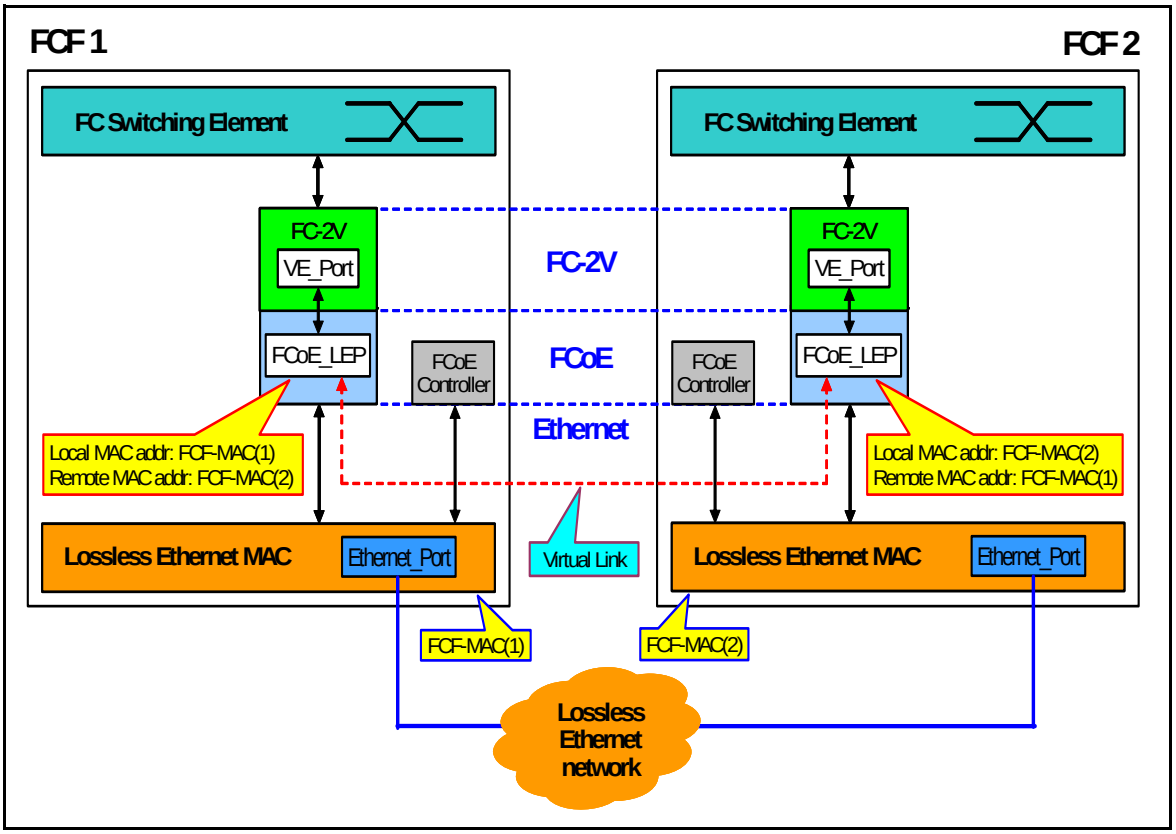

Figure 31 – VE_Port to VE_Port Virtual Links example

On successful completion of a FIP ELP Exchange, the FCoE Controllers of the two involved VE_Port capable FCF-MACs instantiate a VE_Port/FCoE_LEP pair. Figure 31 shows the Virtual Links end-points, that are the MAC addresses of the two involved VE_Port capable FCF-MACs (i.e., FCF-MAC(1) and FCF-MAC(2)).

Figure 32 shows how the models defined in 7.3 and 7.4 model VN_Port to VF_Port Virtual Links.

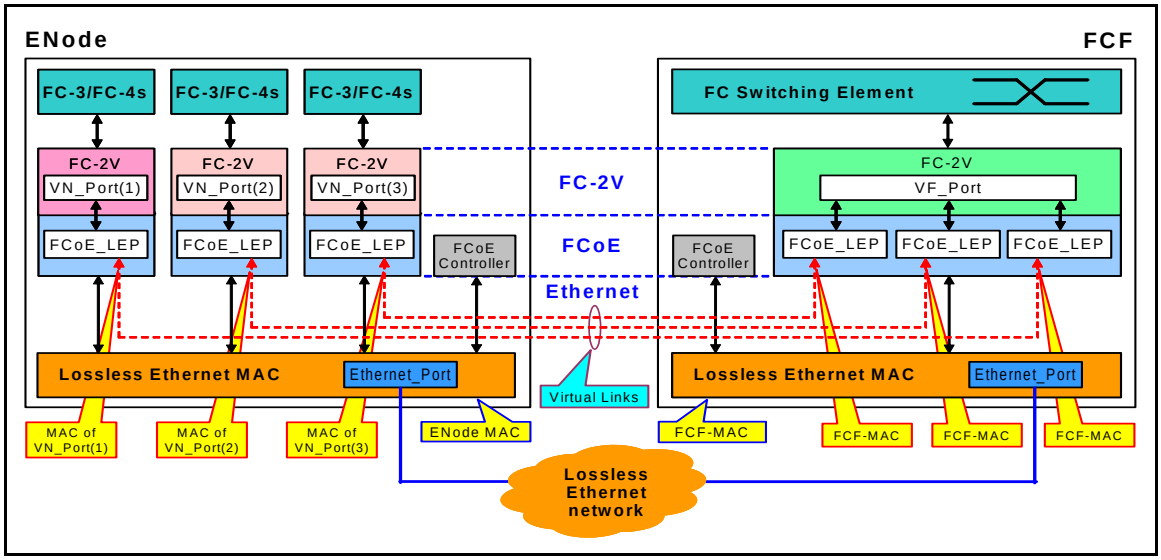

Figure 32 – VN_Port to VF_Port Virtual Links example

On successful completion of a FIP FLOGI Exchange, the FCoE Controller for an ENode MAC instantiates a VN_Port/FCoE_LEP pair (VN_Port(1) in figure 32) and the FCoE Controller of a VF_Port capable FCF-MAC instantiates a VF_Port/FCoE_LEP pair.

On successful completion of a FIP NPIV FDISC Exchange, the FCoE Controller for an ENode MAC instantiates a VN_Port/FCoE_LEP pair (VN_Port(2) in figure 32) and the FCoE Controller of a VF_Port capable FCF-MAC instantiates an additional FCoE_LEP to the instantiated VF_Port.

On successful completion of an additional FIP NPIV FDISC Exchange, the FCoE Controller of an ENode MAC instantiates a VN_Port/FCoE_LEP pair (VN_Port(3) in figure 32) and the FCoE Controller of a VF_Port capable FCF-MAC instantiates an additional FCoE_LEP to the instantiated VF_Port.

Figure 32 shows the Virtual Links end-points, that are the MAC addresses used by the VN_Ports (i.e., MAC of VN_Port(1), MAC of VN_Port(2), and MAC of VN_Port(3)), and the FCF-MAC address.

When SPMAs are used, multiple VN_Ports associated with an ENode MAC may use the same local MAC address to establish Virtual Links to the same VF_Port capable FCF-MAC. In this case, the Fibre Channel addressing information is needed to identify a specific VN_Port to VF_Port Virtual Link in addition to the pair of MAC addresses of the two link end-points. This case is modeled on an ENode MAC with multiple VN_Port/FCoE_LEP pairs, in which the FCoE_LEPs operate using the same local MAC address/remote MAC address pair. Incoming FCoE frames are delivered to the proper VN_Port/FCoE_LEP pair on the basis of the D_ID field. This case is modeled on an FCF-MAC with multiple FCoE_LEPs associated with a VF_Port, in which the FCoE_LEPs operate using the same local MAC address/remote MAC address pair.

7.6 VN_Port MAC addresses

ENodes may support Fabric Provided MAC Addresses (FPMAs) and/or Server Provided MAC Addresses (SPMAs) as VN_Port MAC addresses. The FIP protocol is used to negotiate between ENodes and FCFs which type of VN_Port MAC addresses are used (see 7.8.4.1).

FPMAs are assigned by FCFs while assigning an N_Port_ID to a VN_Port (see 7.8.4.1). A properly formed FPMA is one in which the 24 most significant bits equal the Fabric's FC-MAP value and the least significant 24 bits equal the N_Port_ID assigned to the VN_Port by the FCF. This guarantees that FPMAs are unique within the Fabric. The FC-MAP value is checked by the FIP discovery protocol (see 7.8.3) to ensure it is consistent across the Fabric. FPMAs should not be used for other protocols.

If the FC-MAP value is not administratively configured, then the FC-MAP value shall be set to DEFAULT_FC-MAP (see table 47). If the FC-MAP value is administratively configured, then the FC-MAP value should be in the range 0EFC00h to 0EFCFFh.

SPMAs are assigned by ENodes and validated by FCFs. SPMAs should be globally assigned, not locally generated (i.e., they should have the U/L bit set to zero, see IEEE 802.3-2008). SPMAs used for FCoE and FIP traffic should not be used for other protocols.

7.7 FCoE frame format

An FCoE frame is an Ethernet frame (see 802.3-2008) containing an FCoE PDU. FCoE frames shall be formatted in accordance with 802.3-2008 and the MAC Client Data field within the Ethernet frame shall contain an FCoE PDU (see table 21). The use of an 802.1Q tag header is optional and additional IEEE 802.1 defined tags may be present in an FCoE frame. See Annex B for examples of FCoE frames.

The format of an FCoE PDU is specified in table 21.

Table 21 – FCoE PDU format

Bit / Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Type = FCoE_TYPE																Version				Reserved											
1	Reserved																															
2	Reserved																															
3	Reserved																								SOF							
4	(MSB)																															
n+3	Encapsulated FC Frame (n words)																														(LSB)	
n+4	EOF								Reserved																							

The Type field in the Ethernet header shall be set to FCoE_TYPE (see table 47). The Type field in the Ethernet header is not part of the FCoE PDU.

The Version field shall be set to FCoE_FRAME_VER (see table 47).

The SOF field specifies the SOF delimiter for the encapsulated FC frame. The value of the SOF field shall be as specified in table 22.

Table 22 – FCoE SOF field

Value	Description	Reference
28h	SOFf	FC-FS-3
2Dh	SOFi2	FC-FS-3
35h	SOFn2	FC-FS-3
2Eh	SOFi3	FC-FS-3
36h	SOFn3	FC-FS-3

The Encapsulated FC Frame field shall contain:

a) FC Extended_Header(s) (see FC-FS-3), if any;
b) the FC Frame_Header (see FC-FS-3);
c) the FC Data_Field (see FC-FS-3); and
d) the FC CRC (see FC-FS-3).

The EOF field specifies the EOF delimiter for the encapsulated FC frame. The value of the EOF field shall be set as specified in table 23.

Table 23 – FCoE EOF field

Value	Description	Reference
41h	EOFn	FC-FS-3
42h	EOFt	FC-FS-3
49h	EOFni	FC-FS-3
50h	EOFa	FC-FS-3

7.8 FC-BB_E device initialization

7.8.1 FCoE Initialization Protocol (FIP) overview

The FCoE Initialization Protocol (FIP) is used to perform the functions of FC-BB_E device discovery, initialization, and maintenance. To perform these functions, encapsulated FIP operations (see 7.8.6.2) are specified.

The FIP Ethernet Type (see 7.8.6.1) is different than the FCoE Ethernet Type (see 7.7) to enable the distinction of discovery, initialization, and maintenance traffic from other FCoE traffic.

FIP frames are used to perform the following protocols:

a) FIP VLAN discovery (see 7.8.2);
b) FIP discovery (see 7.8.3);
c) FCoE Virtual Link instantiation (see 7.8.4); and
d) FCoE Virtual Link maintenance (see 7.8.5).

All FIP protocols are performed on a per-VLAN basis. It is recommended to use the FIP VLAN Discovery protocol on the default VLAN (see IEEE 802.1Q-2005). All other FIP protocols shall be performed in each VLAN that provides FC-BB_E services.

In order to provide FC-BB_E services on a VLAN, FCoE and FIP protocols, other than FIP VLAN discovery, shall both be performed on that VLAN. Support for multiple Fabrics per VLAN is outside the scope of this standard.

NOTE 16 – The security provisions of this standard are not sufficient to ensure that FCoE frames remain associated with the correct Fabric if multiple Fabrics are used on the same VLAN.

On ENodes, the ENode MAC address shall be used for all FIP frames, except the VN_Port FIP Keep Alive frame (see 7.8.7.5). On FCFs, the FCF-MAC address shall be used for all FIP frames.

ENode MACs shall listen to the All-ENode-MACs group address, FCF-MACs shall listen to the All-FCF-MACs group address, and both ENode MACs and FCF-MACs shall listen to the All-FCoE-MACs group address.

An ENode MAC shall discard a FIP message destined to an address other than its ENode MAC address or the All-ENode-MACs address.

7.8.2 FIP VLAN discovery protocol

When becoming operational, an ENode MAC or an FCF-MAC may invoke the FIP VLAN discovery protocol to discover the VLANs in the Lossless Ethernet network that provide FC-BB_E services. The FIP VLAN discovery protocol is not needed if these VLANs are already known or if VLANs are not used.

An ENode MAC may send a FIP VLAN Request frame to the All-FCF-MACs MAC address over an available VLAN (e.g., the port VLAN). VF_Port capable FCF-MACs that receive a FIP VLAN Request frame shall respond with a unicast FIP VLAN Notification frame over the same VLAN. The FIP VLAN Notification frame should provide the list of VLAN IDs over which the originating FCF offers FC-BB_E services. The ENode MAC that received a FIP VLAN Notification frame may enable one or more of these VLANs for subsequent operations. VF_Port capable FCF-MACs may limit the number of VLAN IDs listed in a FIP VLAN Notification frame on a per-requester basis.

A VF_Port capable FCF-MAC shall discard a multicast VLAN Request frame that has a source address equal to its FCF-MAC address, and the VLAN Request frame should be reported in a vendor specific way as an indication of a MAC address duplication.

If the configuration of VLANs on which a VF_Port capable FCF-MAC supports FC-BB_E services changes, that FCF-MAC should send a unicast FIP VLAN Notification frame to each ENode MAC address with which that FCF-MAC has established VN_Port to VF_Port Virtual Links. The unicast FIP VLAN Notification frame shall carry the revised list of VLAN IDs over which the originating VF_Port capable FCF-MAC offers FC-BB_E services.

A VE_Port capable FCF-MAC may send a FIP VLAN Request frame to the MAC address All- FCF-MACs over an available VLAN (e.g., the default VLAN). VE_Port capable FCF-MACs that receive a FIP VLAN Request frame shall respond with a unicast FIP VLAN Notification frame over the same VLAN. The FIP VLAN Notification frame carries the list of VLAN IDs over which the originating FCF offers FC-BB_E services. The VE_Port capable FCF-MAC that received a FIP VLAN Notification frame may enable one or more of these VLANs for subsequent operations.

A VE_Port capable FCF-MAC shall discard a multicast VLAN Request frame that has a source address equal to its FCF-MAC address. Such a VLAN Request frame should be reported in a vendor specific way as an indication of a MAC address duplication.

FCF-MACs shall listen to the All-FCF-MACs group address in the default VLAN and in other VLANs that ENodes or FCFs may use to invoke this protocol.

If the configuration of VLANs on which a VE_Port capable FCF-MAC supports FC-BB_E services changes, that FCF-MAC should send a unicast FIP VLAN Notification frame to each FCF-MAC address with which that FCF-MAC has established VE_Port to VE_Port Virtual Links. The unicast FIP VLAN Notification frame shall specify the revised list of VLAN IDs over which the originating VE_Port capable FCF-MAC offers FC-BB_E services.

7.8.3 FIP discovery protocol

7.8.3.1 Overview

On a network deploying multiple VLANs, the FIP discovery protocol is performed in the VLANs where FC-BB_E services are offered when these VLANs are known (e.g., upon performing the FIP VLAN discovery protocol (see 7.8.2)).

7.8.3.2 ENode/FCF discovery

The FCoE Controller of a VF_Port capable FCF-MAC shall periodically transmit multicast Discovery Advertisements (see 7.8.7.3) to the All-ENode-MACs group address every FKA_ADV_PERIOD. The FKA_ADV_PERIOD period shall be randomized by adding a random delay uniformly distributed between 0 and 100 ms to avoid synchronized bursts of multicast traffic within the Ethernet network. The FCoE Controller of a VF_Port capable FCF-MAC should begin transmitting unsolicited multicast Discovery Advertisements on completion of Fabric configuration (see FC-SW-5).

On receiving Discovery Advertisements, the FCoE Controller of an ENode MAC shall verify the VN_Port addressing capabilities of the advertising FCF-MAC (i.e., the values of the FP and SP flags, see table 27) against its VN_Port addressing capabilities. The FCoE Controller of an ENode MAC shall discard incompatible Discovery Advertisements and shall create an entry for each compatible FCF-MAC in an internal FCF list.

NOTE 17 – The internal data structures used to describe this protocol are a model to express the behavior, not an implementation requirement.

Each entry in the FCF list has the following flags:

a) ‘Max FCoE Size Verified’ - set to zero for entries created from unsolicited multicast Discovery Advertisements, set to one when a solicited unicast Discovery Advertisement is received; and
b) ‘Available for Login’ - reflects the value of the A bit provided by the most recently received Discovery Advertisement from that VF_Port capable FCF-MAC.

The FCoE Controller of an ENode MAC selects for login a subset of the FCF-MACs in the FCF list having the ‘Available for Login’ flag set to one (i.e., the FCF Login Set) on the basis of a local policy that should default to selecting the one(s) with higher priority (i.e., lower priority value) in the absence of explicit configuration of other selection criteria. A FIP FLOGI may be performed with an FCF-MAC in the FCF Login Set only if its ‘Max FCoE Size Verified’ flag is set to one. In order to perform a FIP FLOGI with an FCF-MAC in the FCF Login Set with the ‘Max FCoE Size Verified’ flag set to zero, the FCoE Controller of an ENode MAC shall transmit a unicast Discovery Solicitation (see 7.8.7.2) to that FCF-MAC address and receive a solicited unicast Discovery Advertisement in response.

The periodic reception of unsolicited multicast Discovery Advertisements allows the FCoE Controller of ENode MACs to continuously verify FCF-MAC connectivity. The Available for Login (A) bit in received Discovery Advertisements provides the information that the transmitting FCF-MAC is available for FIP FLOGI/FDISC, and this information is updated in the FCF list and FCF Login Set on reception of Discovery Advertisements. The A bit is informational and shall have no effect on existing logins.

When the FCoE Controller of an ENode MAC becomes operational it should discover VF_Port capable FCF-MACs with which it may perform FIP FLOGI by transmitting a multicast Discovery Solicitation to the All-FCF-MACs group address. In response to a Discovery Solicitation from an ENode MAC, a VF_Port capable FCF-MAC shall transmit a solicited unicast Discovery Advertisement to the soliciting ENode MAC if its VN_Port addressing modes are compatible with the modes of the ENode MAC (see table 27) and if it is configured to allow a FIP FLOGI from that ENode. The solicited unicast Discovery Advertisement shall be transmitted to the MAC address specified in the MAC address descriptor in the received Discovery Solicitation. The solicited unicast Discovery Advertisement shall be transmitted within ADV_TOV (see table 47) upon reception of the Discovery Solicitation. Discovery Advertisements transmitted in response to a multicast Discovery Solicitation should be delayed by a random time uniformly distributed between 0 and 100 ms to avoid synchronized bursts of multicast traffic within the Ethernet network. This delay should not be applied to solicited unicast Discovery Advertisements sent in response to unicast Discovery Solicitations. Solicited unicast Discovery Advertisements should not be transmitted until Fabric configuration (see FC-SW-5) is completed.

NOTE 18 – An ENode MAC may also wait to receive unsolicited multicast Discovery Advertisements and then send unicast Discovery Solicitations to the FCF-MACs selected for login from the FCF Login set.

A Discovery Solicitation shall carry in the Max FCoE Size descriptor the maximum FCoE PDU size the ENode MAC intends to use for FCoE traffic (see 7.8.6.3.7). The FIP PDU (see table 24) in a solicited unicast Discovery Advertisement shall be extended to have a length that matches the Max_FCoE_Size field value in the Max FCoE Size descriptor in the Discovery Solicitation that the Discovery Advertisement is responding to (see 7.8.7.3).

NOTE 19 – If an ENode transmits an FCoE frame with an FCoE PDU size that is greater than its maximum FCoE PDU size, the network may not deliver the FCoE frame.

An ENode MAC may generate multiple Discovery Solicitations.

NOTE 20 – As an example, an ENode MAC that does not receive a solicited unicast Discovery Advertisement in response to a Discovery Solicitation may transmit additional Discovery Solicitations, unicast or multicast.

Reception of a solicited unicast Discovery Advertisement from an FCF-MAC shall set the ‘Max FCoE Size Verified’ flag to one in the entry for that FCF-MAC in the FCF Login Set of an ENode MAC.

It is possible for an FCF to receive a multicast Discovery Solicitation from the same ENode MAC on multiple FCF-MACs. In this case, a separate solicited unicast Discovery Advertisement shall be transmitted by each of the FCF-MACs that received the Discovery Solicitation. The ENode MAC that transmitted the multicast Discovery Solicitation is able to determine that it received multiple solicited unicast Discovery Advertisements from the same FCF since the value of the Name_Identifer field in the Name_Identifier descriptor is the same in each of the solicited unicast Discovery Advertisements (see 7.8.7.3). In this case the ENode MAC should select the FCF-MAC for Fabric login with that FCF based on the value of the Priority descriptor in the Discovery Advertisements.

It is possible for an ENode MAC to receive multiple unsolicited multicast Discovery Advertisements from multiple FCF-MACs of the same FCF. The ENode MAC is able to determine that those

unsolicited multicast Discovery Advertisements are from the same FCF since the value of the Name_Identifer field in the Name_Identifier descriptor is the same in each of the unsolicited multicast Discovery Advertisements (see 7.8.7.3). In this case the ENode MAC should select the FCF-MAC for Fabric login with that FCF based on the value of the Priority descriptor in the Discovery Advertisements.

An ENode MAC shall discard any received Discovery Solicitation. A VF_Port capable FCF-MAC shall discard any Discovery Solicitation originated by a VE_Port capable FCF-MAC (i.e., having the F bit set to one (see 7.8.6.2)).

An ENode MAC shall discard an unsolicited multicast Discovery Advertisement that has a source address equal to its ENode MAC address. Such a Discovery Advertisement should be reported in a vendor specific way as an indication of a MAC address duplication.

A VF_Port capable FCF-MAC shall discard a multicast Discovery Solicitation that has a source address equal to its FCF-MAC address. Such a Discovery Solicitation should be reported in a vendor specific way as an indication of a MAC address duplication.

Reception of Discovery Advertisements for more than one Fabric on the same VLAN should be reported by an ENode MAC in a vendor specific manner and no subsequent VN_Port to VF_Port Virtual Links should be instantiated.

7.8.3.3 FCF/FCF discovery

The FCoE Controller of a VE_Port capable FCF-MAC shall periodically transmit multicast Discovery Advertisements (see 7.8.7.3) to the All-FCF-MACs group address every FKA_ADV_PERIOD. The FKA_ADV_PERIOD period shall be randomized by adding a random delay uniformly distributed between 0 and 100 ms to avoid synchronized bursts of multicast traffic within the Ethernet network.

On receiving Discovery Advertisements, the FCoE Controller of a VE_Port capable FCF-MAC shall create an entry per FCF-MAC in an internal FCF list.

NOTE 21 – The internal data structures used to describe this protocol are a model to express the behavior, not an implementation requirement.

Each entry in the FCF list has the following flags:

a) ‘Max FCoE Size Verified’ - set to zero for entries created from unsolicited multicast Discovery Advertisements, set to one when a solicited unicast Discovery Advertisement is received; and
b) ‘Available for ELP’ - reflects the value of the A bit provided by the most recently received Discovery Advertisement from that VE_Port capable FCF-MAC.

A FIP ELP may be performed with an FCF-MAC in the FCF list only if its ‘Max FCoE Size Verified’ flag is set to one. In order to perform a FIP ELP with an FCF-MAC in the FCF list with the ‘Max FCoE Size Verified’ flag set to zero, the FCoE Controller of a VE_Port capable FCF-MAC shall transmit a unicast Discovery Solicitation (see 7.8.7.2) to that FCF-MAC address and receive a solicited unicast Discovery Advertisement in response.

The periodic reception of unsolicited multicast Discovery Advertisements allow the FCoE Controller of VE_Port capable FCF-MACs to continuously verify the FCF-MACs connectivity. The ‘Available for Login’ (A) bit in received Discovery Advertisements provides the information that the transmitting FCF-MAC is available for FIP ELP, and this information is updated in the FCF list on reception of Advertisements. The A bit is informational and shall have no effect on existing VE_Port to VE_Port Virtual Links.

When the FCoE Controller for a VE_Port capable FCF-MAC becomes operational it should discover other VE_Port capable FCF-MACs by transmitting a multicast Discovery Solicitation to the All-FCF-MACs group address. In response to a Discovery Solicitation from an FCF-MAC, a VE_Port capable FCF-MAC shall transmit a solicited unicast Discovery Advertisement to the soliciting FCF-MAC if the FC-MAP value in the Discovery Solicitation is compatible with the FC-MAP configured on the FCF and if it is configured to allow a Virtual Link with that FCF.

The solicited unicast Discovery Advertisement shall be transmitted to the MAC address specified in the MAC address descriptor in the received Discovery Solicitation. The solicited unicast Discovery Advertisement shall be transmitted within ADV_TOV (see table 47) upon reception of the Discovery Solicitation. Discovery Advertisements transmitted in response to a multicast Discovery Solicitation should be delayed by a random time uniformly distributed between 0 and 100 ms to avoid synchronized bursts of multicast traffic within the Ethernet network. This delay should not be applied to solicited unicast Discovery Advertisements sent in response to unicast Discovery Solicitations.

NOTE 22 – A VE_Port capable FCF-MAC may also wait to receive unsolicited multicast Discovery Advertisements and then send unicast Discovery Solicitations to the FCF-MACs in the FCF list.

A Discovery Solicitation shall specify in the Max FCoE Size descriptor (see 7.8.6.3.7) the maximum FCoE PDU size the VE_Port capable FCF-MAC intends to use for FCoE traffic. The FIP PDU (see table 24) in a solicited unicast Discovery Advertisement shall be extended to have a length that matches the Max_FCoE_Size field value in the Max FCoE Size descriptor in the Discovery Solicitation that the Discovery Advertisement is responding to (see 7.8.7.3).

NOTE 23 – If a VE_Port capable FCF-MAC transmits an FCoE frame with an FCoE PDU size that is greater than its maximum FcoE PDU size, the network may not deliver the FCoE frame.

A VE_Port capable FCF-MAC may generate multiple Discovery Solicitations.

NOTE 24 – As an example, a VE_Port capable FCF-MAC that does not receive a solicited unicast Discovery Advertisement in response to a Discovery Solicitation may transmit additional Discovery Solicitations.

Reception of a solicited unicast Discovery Advertisement from an FCF-MAC shall set the ‘Max FCoE Size Verified’ flag to one in the entry for that FCF-MAC in the FCF list of the receiving VE_Port capable FCF-MAC.

It is possible for an FCF to receive multicast Discovery Solicitations from the same VE_Port capable FCF-MAC on multiple FCF-MACs. In this case, a separate solicited unicast Discovery Advertisement shall be transmitted by each of the FCF-MACs that received the Discovery Solicitation. The VE_Port capable FCF-MAC that transmitted the multicast Discovery Solicitation is able to determine that it received multiple solicited unicast Discovery Advertisements from the same FCF since the value of the Name_Identifer field in the Name_Identifier descriptor is the same in each of the solicited unicast Discovery Advertisements (see 7.8.7.3).

It is possible for a VE_Port capable FCF-MAC to receive multiple unsolicited multicast Discovery Advertisements from multiple FCF-MACs of the same FCF. The VE_Port capable FCF-MAC is able to determine that those unsolicited multicast Discovery Advertisements are from the same FCF since the value of the Name_Identifer field in the Name_Identifier descriptor is the same in each of the unsolicited multicast Discovery Advertisements (see 7.8.7.3).

After receiving a Discovery Solicitation originated by an FCF (i.e., the F bit is set to one), an FCF-MAC shall perform the following verification checks:

a) the Name_Identifier field value in the Discovery Solicitation is different than the Switch_Name of the recipient FCF (see 7.8.7.2.2); and
b) either:
   A) the FP bit is set to one (see 7.8.6.2) and the FC-MAP value in the FC-MAP descriptor in the Discovery Solicitation is the same as the FC-MAP value of the recipient FCF; or
   B) the FP bit is set to zero, the SP bit is set to one (see 7.8.6.2), and the FC-MAP value in the FC-MAP descriptor in the Discovery Solicitation is zero.

If any verification check is false, then the Discovery Solicitation shall be discarded.

After receiving a Discovery Advertisement, an FCF-MAC shall perform the following verification checks:

a) the Name_Identifier field value in the Discovery Advertisement is different than the Switch_Name of the recipient FCF (see 7.8.7.3); and
b) either:
   A) the FP bit is set to one (see 7.8.6.2) and the FC-MAP value in the Fabric descriptor in the Discovery Advertisement is the same as the FC-MAP value of the recipient FCF; or
   B) the FP bit is set to zero, the SP bit is set to one (see 7.8.6.2), and the FC-MAP value in the Fabric descriptor in the Discovery Advertisement is zero.

If any verification check is false, then the Discovery Advertisement shall be discarded.

NOTE 25 – It is possible for an FCF to receive a multicast Discovery Solicitation or a multicast Discovery Advertisement that it originated because FIP frames sent to the All-FCF-MACs group address may be forwarded to other ports on the same FCF by intermediate Ethernet bridges.

A VE_Port capable FCF-MAC shall discard any Discovery Solicitation originated by an ENode (i.e., having the F bit set to zero (see 7.8.6.2)).

A VE_Port capable FCF-MAC shall discard a multicast Discovery Solicitation that has a source address equal to its FCF-MAC address. Such a Discovery Solicitation should be reported in a vendor specific way as an indication of a MAC address duplication.

Reception of Discovery Advertisements for more than one Fabric on the same VLAN should be reported by VE_Port capable FCF-MAC in a vendor specific manner and no subsequent VE_Port to VE_Port Virtual Links should be instantiated.

7.8.4 FCoE Virtual Link instantiation protocol

7.8.4.1 VN_Port to VF_Port Virtual Links

The FCoE Controller of an ENode MAC instantiates VN_Port to VF_Port Virtual Links on successful completion of a FIP Fabric login request. Fabric login (i.e., FLOGI, NPIV FDISC) shall be performed using FIP frames (see table 24) and the associated FIP descriptor type (see table 29). Fabric login (i.e., FLOGI, NPIV FDISC) shall not be performed using FCoE frames .

In addition to providing Fabric login, the FIP Fabric login provides a method to assign a MAC address for the VN_Port (see 7.8.7.4.2).

When the FCoE Controller of an ENode MAC transmits a FIP FLOGI Request or FIP NPIV FDISC Request it shall indicate the addressing mode it intends to use (i.e., FPMA, SPMA, or both (see table 27)). The MAC address returned by the FCF in a FIP FLOGI LS_ACC or FIP NPIV FDISC LS_ACC shall be used as the VN_Port MAC address (see 7.6).

If the SP bit is set to one in a FIP FLOGI Request or FIP NPIV FDISC Request (see table 27) and the FCF selects to use SPMA, the FCF shall return the MAC address specified in the FIP FLOGI Request or FIP NPIV FDISC Request in the FIP FLOGI LS_ACC or FIP NPIV FDISC LS_ACC, if that MAC address is valid (see 7.8.6.3.3).

If the FP bit is set to one in a FIP FLOGI Request or FIP NPIV FDISC Request (see table 27) and the FCF selects to use FPMA, the FCF shall return a properly formed FPMA MAC address in the FIP FLOGI LS_ACC or FIP NPIV FDISC LS_ACC (see 7.6).

If both the FCF and ENode support both SPMA and FPMA, the FCF shall select a type and shall return a MAC address for the selected type.

Explicit VN_Port to VF_Port Virtual Link de-instantation is performed by an ENode MAC by performing Fabric logout. Fabric logout (i.e., Fabric LOGO) shall be performed by an ENode using FIP frames (see table 24) and the associated FIP descriptor type (see table 29). Fabric logout shall not be performed using FCoE frames.

In addition to providing Fabric logout, the FIP Fabric logout provides a method to de-assign a MAC address for the VN_Port (see 7.8.7.4.3).

7.8.4.2 VE_Port to VE_Port Virtual Links

The FCoE Controller of a VE_Port capable FCF-MAC instantiates VE_Port to VE_Port Virtual Links on successful completion of a FIP ELP request. ELP shall be performed using FIP frames (see table 24) and the associated FIP descriptor type (see table 29). ELP shall not be performed using FCoE frames.

In addition to providing ELP, the FIP ELP provides a method to communicate the MAC address for the VE_Port (see 7.8.7.4.4).

7.8.5 FCoE Virtual Link maintenance protocol

7.8.5.1 Virtual Link maintenance protocol overview

VN_Port to VF_Port Virtual Links (see figure 27) and VE_Port to VE_Port Virtual Links (see figure 28) overlay over a Lossless Ethernet network. The Virtual Link maintenance protocol specifies how to deal with faults that may occur in a Lossless Ethernet network.

7.8.5.2 VN_Port to VF_Port Virtual Link maintenance protocol

To deal with local physical layer faults, an ENode MAC shall de-instantiate all its VN_Ports to VF_Port Virtual Links upon detecting that its physical layer is not operational. This condition shall be handled as an implicit Fabric logout (see FC-LS-2) for the involved VN_Ports. A VF_Port capable FCF-MAC shall de-instantiate all its VF_Ports upon detecting that its physical layer is not operational.

To deal with non-local faults, the FCoE Controllers of an ENode MAC and of a VF_Port capable FCF-MAC shall continuously verify the state of the VN_Port to VF_Port Virtual Link by transmitting appropriate FIP frames and by verifying received FIP frames. This behavior may be disabled by VF_Port capable FCF-MACs under administrative control by setting to one the D bit in the FKA_ADV_Period descriptor in Discovery Advertisements (see 7.8.6.3.13). The D bit in the FKA_ADV_Period descriptor may be set to one only in a direct-attach topology (i.e., when an ENode is directly connected to an FCF without any intermediate Ethernet bridges).

The FCoE Controller of an ENode MAC shall transmit a unicast FIP Keep Alive frame on behalf of the ENode MAC (i.e., with the ENode MAC address as source MAC address and without a Vx_Port Identification descriptor in the FIP Descriptor list (see table 45)) to each VF_Port capable FCF-MAC with which it has VN_Ports logged in. This ENode FIP Keep Alive frame shall be transmitted every FKA_ADV_PERIOD. The FKA_ADV_PERIOD is obtained from the Discovery Advertisements received from the VF_Port capable FCF-MACs with which the ENode MAC has VN_Ports logged in.

In addition, the FCoE Controller of an ENode MAC shall transmit a unicast FIP Keep Alive frame on behalf of each VN_Port (i.e., with the VN_Port MAC address as source MAC address and containing a Vx_Port Identification descriptor for that VN_Port in the FIP Descriptor list, see table 45) to the VF_Port capable FCF-MAC with which that VN_Port is logged in. This VN_Port FIP Keep Alive frame shall be transmitted every FKA_VN_PERIOD.

The FCoE Controller of an ENode MAC shall monitor the status of a VF_Port with which it has VN_Ports logged in by verifying reception of unsolicited multicast Discovery Advertisements from that VF_Port capable FCF-MAC. Unsolicited multicast Discovery Advertisements are expected to be received every FKA_ADV_PERIOD. If unsolicited multicast Discovery Advertisements are not received within 2.5 * FKA_ADV_PERIOD, all the VN_Port to VF_Port Virtual Links with that VF_Port shall be implicitly de-instantiated. This condition should be counted as a Virtual Link failure and shall be handled as an implicit Fabric logout (see FC-LS-2) for the involved VN_Ports. That FCF-MAC shall be removed from the FCF Login Set (see 7.8.3.2). A subsequent FIP Fabric Login may be performed with an FCF-MAC in the current FCF Login Set as specified in see 7.8.3.2.

The FCoE Controller of a VF_Port capable FCF-MAC shall transmit an unsolicited multicast Discovery Advertisement to the All-ENode-MACs group address every FKA_ADV_PERIOD.

The FCoE Controller of a VF_Port capable FCF-MAC shall monitor the status of an ENode MAC with which it has active VN_Port to VF_Port Virtual Links by verifying the reception of FIP Keep Alive frames from that ENode MAC and its VN_Ports. VN_Port FIP Keep Alive frames (i.e., those containing a Vx_Port Identification descriptor) are expected to be received every FKA_VN_PERIOD and ENode FIP Keep Alive frames (i.e., those not containing a Vx_Port Identification descriptor) are expected to be received every FKA_ADV_PERIOD.

If VN_Port FIP Keep Alive frames are not received within 2.5 * FKA_VN_PERIOD, the associated VN_Port to VF_Port Virtual Link shall be explicitly de-instantiated (i.e., a FIP Clear Virtual Links frame listing the unreachable VN_Port shall be generated). This condition shall be handled as an implicit Fabric logout (see FC-LS-2) for the involved VN_Port. If ENode FIP Keep Alive frames are not received within 2.5 * FKA_ADV_PERIOD, all associated VN_Port to VF_Port Virtual Links shall be explicitly de-instantiated (i.e., a FIP Clear Virtual Links frame listing all the unreachable VN_Ports shall be generated). This condition shall be handled as an implicit Fabric logout (see FC-LS-2) for the involved VN_Ports.

NOTE 26 – The use of a faster FKA_ADV_PERIOD rate for ENode FIP Keep Alive frames allows fast response times against loss of connectivity in the Ethernet realm with limited overhead. The use of VN_Port FIP Keep Alive frames transmitted at a slower FKA_VN_PERIOD rate allows the clearing of state associated with each individual VN_Port when that VN_Port becomes not operational.

Explicit VN_Port to VF_Port Virtual Link de-instantation is invoked by a VF_Port capable FCF-MAC by transmitting a FIP Clear Virtual Links frame (see 7.8.7.6). A FIP Clear Virtual Links frame transmitted to an ENode MAC with logged in VN_Ports provides the list of VN_Ports to be removed. An ENode MAC shall de-instantiate the VN_Ports listed in a FIP Clear Virtual Link frame upon reception of the FIP frame. This condition shall be handled as an implicit Fabric logout (see FC-LS-2) for the involved VN_Ports.

The size of a FIP Clear Virtual Links frame shall not exceed the standard Ethernet MAC Client Data size (i.e., 1 500 bytes for basic frames and 1 504 bytes for Q-tagged frames, see IEEE 802.3-2008). If the list of VN_Ports to be removed does not fit in a single FIP frame, multiple FIP frames should be transmitted to convey the entire list.

On receiving a VN_Port FIP Keep Alive frame coming from a VN_Port that is not logged, the FCoE Controller of a VF_Port capable FCF-MAC shall transmit a FIP Clear Virtual Links frame listing that VN_Port.

On receiving an ENode FIP Keep Alive frame coming from an ENode MAC that is not logged in, the FCoE Controller of a VF_Port capable FCF-MAC shall transmit a FIP Clear Virtual Links frame listing no VN_Ports. A FIP Clear Virtual Links frame listing no VN_Ports shall be handled by an ENode MAC by de-instantiating all VN_Port to VF_Port Virtual Links with that VF_Port capable FCF-MAC. This condition shall be handled as an implicit Fabric logout (see FC-LS-2) for the involved VN_Ports.

FIP Clear Virtual Links frames may be generated by FCFs whenever appropriate to speed-up fault recovery.

NOTE 27 – As an example, in certain topologies an FCF may generate a FIP Clear Virtual Links frame to de-instantiate the VN_Port to VF_Port Virtual Links affected by a local physical layer fault on other ports upon detection of that fault.

The FKA_ADV_PERIOD value (see table 47) may be changed on a FCF under administrative control. When this happens, each VF_Port capable FCF-MAC of the FCF shall advertise the updated FKA_ADV_PERIOD in subsequent unsolicited multicast Discovery Advertisements.

When the FKA_ADV_PERIOD value is decreased, a VF_Port capable FCF-MAC shall transmit unsolicited multicast Discovery Advertisements at the interval specified by the updated value, but shall not use the updated value for detection of missing ENode FIP Keep Alives until five times the old value has elapsed since the transmission of the first updated unsolicited multicast Discovery Advertisement.

When the FKA_ADV_PERIOD value is increased, a VF_Port capable FCF-MAC shall transmit unsolicited multicast Discovery Advertisements at the interval specified by the old value until five times the updated value has elapsed since the transmission of the first updated unsolicited multicast Discovery Advertisement, but shall use the updated value for detection of missing ENode FIP Keep Alives.

On detecting the updated value, an ENode having VN_Port to VF_Port Virtual Links instantiated with that FCF shall transmit ENode FIP Keep Alive frames at the interval specified by the updated FKA_ADV_PERIOD value and shall use the updated value for detection of missing unsolicited multicast Discovery Advertisements.

7.8.5.3 VE_Port to VE_Port Virtual Link maintenance protocol

To deal with local physical layer faults, a VE_Port capable FCF-MAC shall de-instantiate all its VE_Port to VE_Port Virtual Links upon detecting that its physical layer is not operational.

To deal with non-local faults, the FCoE Controllers for VE_Port capable FCF-MACs shall continuously verify the state of a VE_Port to VE_Port Virtual Link by transmitting unsolicited multicast Discovery Advertisements and by verifying received unsolicited multicast Discovery Advertisements.

The FCoE Controller for a VE_Port capable FCF-MAC shall transmit a Discovery Advertisement to the All-FCF-MACs group address every FKA_ADV_PERIOD.

The FCoE Controller for a VE_Port capable FCF-MAC shall monitor the status of a VE_Port to VE_Port Virtual Link by verifying the reception of unsolicited multicast Discovery Advertisements. Unsolicited multicast Discovery Advertisements are expected to be received every FKA_ADV_PERIOD. If unsolicited multicast Discovery Advertisements are not received within 2.5 * FKA_ADV_PERIOD, the VE_Port to VE_Port Virtual Link associated with that FCF-MAC shall be explicitly de-instantiated along with the associated VE_Port. That FCF-MAC shall be removed from the FCF List (see 7.8.3.3).

Explicit VE_Port to VE_Port Virtual Link de-instantation is performed by transmitting a FIP Clear Virtual Links frame from a VE_Port capable FCF-MAC. A FIP Clear Virtual Links frame transmitted to a VE_Port capable FCF-MAC provides the destination FCF-MAC address in the Vx_Port Identification descriptor. A VE_Port capable FCF-MAC shall de-instantiate the VE_Port listed in a FIP Clear Virtual Link frame upon reception of the FIP frame.

The FKA_ADV_PERIOD value (see table 47) may be changed on a FCF under administrative control. When this happens, each VE_Port capable FCF-MAC of the FCF shall advertise the updated FKA_ADV_PERIOD in subsequent unsolicited multicast Discovery Advertisements and shall transmit them at the interval specified by the updated value.

On detecting the updated value in received unsolicited multicast Discovery Advertisements, a VE_Port capable FCF-MAC shall use the updated value for detection of missing unsolicited multicast Discovery Advertisements.

7.8.6 FIP frames

7.8.6.1 FIP frame format

A FIP frame is an Ethernet frame (see 802.3-2008) containing a FIP PDU. FIP frames shall be formatted in accordance with 802.3-2008 and the MAC Client Data field within the Ethernet frame shall contain a FIP PDU (see table 24). The use of an 802.1Q tag header is optional and additional IEEE 802.1 defined tags may be present in a FIP frame. See Annex B for examples of FIP frames.

The format of a FIP PDU is specified in table 24.

Table 24 – FIP PDU format

Bit / Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Type = FIP_TYPE																Version				Reserved											
1	(MSB)																															
n	Encapsulated FIP operation (n words)																															(LSB)

The Type field in the Ethernet header shall be set to FIP_TYPE (see table 47). The Type field is not part of the FIP PDU.

The Version field shall be set to FIP_FRAME_VER (see table 47).

The Encapsulated FIP operation field shall be as specified in 7.8.6.2.

A received FIP frame containing no encapsulated FIP operation shall be discarded.

7.8.6.2 Encapsulated FIP operation

The format of the encapsulated FIP operation is specified in table 25.

Table 25 – Encapsulated FIP operation format

Bit / Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	FIP Protocol Code																Reserved								FIP Subcode							
1	FIP Descriptor List Length																FP	SP	Reserved											A	S	F
2	FIP Descriptor List (m words)																															
n-1	FIP_Pad (n-m-2 words)																															

The FIP Protocol Code and FIP Subcode field values and operations are specified in table 26.

Table 26 – FIP Protocol Code and FIP Subcode field values

FIP Protocol Code	FIP Subcode	FIP Operation	Reference
0001h	01h	Discovery Solicitation	7.8.7.2
	02h	Discovery Advertisement	7.8.7.3
0002h	01h	Virtual Link Instantiation Request	7.8.7.4
	02h	Virtual Link Instantiation Reply	7.8.7.4
0003h	01h	FIP Keep Alive	7.8.7.5
	02h	FIP Clear Virtual Links	7.8.7.6
0004h	01h	FIP VLAN Request	7.8.7.7
	02h	FIP VLAN Notification	7.8.7.8
FFF8h to FFFEh	00h to FFh	Vendor Specific	7.8.7.9
All others	All others	Reserved	

The FIP Descriptor List Length field shall be set to the length in words of all FIP descriptor(s) that follow. A receiver shall ignore any data beyond the length specified in this field.

The Fabric Provided (FP) bit and Server Provided (SP) bit settings are dependent on the FIP operation and shall be set as specified in table 27

Table 27 – FP bit and SP bit setting

Bit	FIP Protocol	FIP Operation (see table 45)	Setting
FP	Discovery	Discovery Solicitation[a]	Set to one if the originating device supports FPMA. Set to zero if the originating device does not support FPMA.
		Discovery Advertisement[a]	Set to one if the originating device supports FPMA. Set to zero if the originating device does not support FPMA.
	Virtual Link Instantiation	FIP FLOGI Request[b]	Set to one if FPMA is requested. Set to zero if FPMA is not requested.
		FIP NPIV FDISC Request[b]	Set to one if FPMA is requested. Set to zero if FPMA is not requested.
		FIP FLOGI LS_ACC[c]	Set to one if FPMA is granted. Set to zero if FPMA is not granted.
		FIP NPIV FDISC LS_ACC[c]	Set to one if FPMA is granted. Set to zero if FPMA is not granted.
	All others	All others	Reserved
SP	Discovery	Discovery Solicitation[a]	Set to one if the originating device supports SPMA. Set to zero if the originating device does not support SPMA.
		Discovery Advertisement[a]	Set to one if the originating device supports SPMA. Set to zero if the originating device does not support SPMA.
	Virtual Link Instantiation	FIP FLOGI Request[b]	Set to one if SPMA is requested. Set to zero if SPMA is not requested.
		FIP NPIV FDISC Request[b]	Set to one if SPMA is requested. Set to zero if SPMA is not requested.
		FIP FLOGI LS_ACC[c]	Set to one if SPMA is granted. Set to zero if SPMA is not granted.
		FIP NPIV FDISC LS_ACC[c]	Set to one if SPMA is granted. Set to zero if SPMA is not granted.
	All others	All others	Reserved

a Solicitation or Advertisement frames with the FP and SP bits both set to zero should not be transmitted and such frames shall be ignored on reception.
b Both the FP bit and SP bit may be set to one in a FIP FLOGI Request or FIP NPIV FDISC Request, but at least one of the bits shall be set to one.
c Only one of the FP bit and SP bit shall be set to one in a FIP FLOGI LS_ACC or FIP NPIV FDISC LS_ACC. They shall not have the same value.

The Solicited (S) bit shall be set to one in solicited unicast Discovery Advertisements (i.e., Discovery Advertisements transmitted in response to a Discovery Solicitation). The S bit shall be set to zero in unsolicited multicast Discovery Advertisements (i.e., Discovery Advertisements not transmitted in response to a Discovery Solicitation). The S bit is reserved for all other FIP operations.

The FCF (F) bit shall be set to one in a Discovery Solicitation, Discovery Advertisement, or FIP VLAN Request if the originating device is an FCF. The F bit shall be set to zero in a Discovery Solicitation, Discovery Advertisement, or in a FIP VLAN Request if the originating device is not an FCF. The F bit is reserved for all other FIP operations.

The Available for Login (A) bit shall be set to one in a Discovery Advertisement if the originating FCF is available to process FIP FLOGI, FIP NPIV FDISC, or FIP ELP Requests (see 7.8.3). The A bit shall be set to zero in a Discovery Advertisement if the originating FCF is not available to process FIP FLOGI, FIP NPIV FDISC, or FIP ELP Requests. The A bit is reserved for all other FIP operations.

The FIP Descriptor List field shall contain one or more FIP descriptors (see 7.8.6.3).

The FIP_Pad field shall be used in solicited unicast Discovery Advertisements to extend the FIP PDU (see table 24) to have a length that matches the Max_FCoE_Size field value in the Max FCoE Size descriptor in the Discovery Solicitation that the Discovery Advertisement is responding to (see 7.8.7.3). The FIP_Pad field shall be of zero length (i.e., not present) for all other FIP operations.

Received FIP frames shall be checked for correct formatting before any FIP descriptor processing occurs. A malformed FIP frame shall be discarded and should be reported in a vendor specific way. The checks for correct formatting include:

a) the FIP Descriptor List Length value matches the sum of the descriptors' lengths in the FIP Descriptor List;
b) the FIP Protocol Code field and FIP Subcode field are valid (see table 26);
c) the critical descriptors (see 7.8.6.3.1) required by the FIP Protocol Code and FIP Subcode are present;
d) no critical descriptors other than the ones required by the FIP Protocol Code and FIP Subcode are present; and
e) descriptors use valid values for MAC addresses (see 7.8.6.3.3), FKA_ADV_PERIOD (see table 47) and VLAN IDs (see 7.8.6.3.15).

7.8.6.3 FIP descriptors

7.8.6.3.1 FIP descriptor overview

FIP descriptors are specified using a TLV format (i.e., Type, Length, Value). The length field value shall be specified as the number of words in the FIP descriptor including the TLV format. FIP descriptor type values are split into two ranges, critical and non-critical, as specified in table 28.

Table 28 – FIP descriptor type value ranges

Range	Value	Description
Critical	0 to 127	An FCoE Controller that receives a FIP frame with an unknown critical descriptor shall discard the FIP frame.
Non-critical	128 to 255	An FCoE Controller that receives a FIP frame with one or more unknown non-critical descriptors shall ignore the unknown descriptors and continue to process the FIP frame.

A descriptor with an invalid length value shall be considered invalid. If that descriptor is critical, the entire FIP operation shall be discarded. If that descriptor is not critical, the descriptor shall be ignored.

The FIP descriptor types are specified in table 29. See table 45 for how FIP descriptors are used.

Table 29 – FIP descriptor types

Range	Type	FIP Descriptor	Reference
Critical	0	Reserved	
	1	Priority	7.8.6.3.2
	2	MAC address	7.8.6.3.3
	3	FC-MAP	7.8.6.3.4
	4	Name_Identifier	7.8.6.3.5
	5	Fabric	7.8.6.3.6
	6	Max FCoE Size	7.8.6.3.7
	7	FLOGI[a]	7.8.6.3.8
	8	NPIV FDISC[a]	7.8.6.3.9
	9	LOGO[a]	7.8.6.3.10
	10	ELP[a]	7.8.6.3.11
	11	Vx_Port Identification	7.8.6.3.12
	12	FKA_ADV_Period	7.8.6.3.13
	13	Vendor_ID	7.8.6.3.14
	14	VLAN	7.8.6.3.15
	15 to 127	Reserved	
Non-critical	128 to 240	Reserved	
	241 to 254	Vendor Specific	7.8.6.3.16
	255	Reserved	

a The FC CRC, SOF, and EOF shall not be included in the FIP descriptor.

7.8.6.3.2 FIP Priority descriptor

The FIP Priority descriptor is used in FIP operations as specified in table 45. An ENode may use the value provided in the Priority descriptor of received Discovery Advertisements to select the FCF-MAC to which to perform FIP FLOGI. The default value for the Priority field is DEFAULT_FIP_PRIORITY (see table 47). The highest priority value is 0 and the lowest priority value is 255 (i.e., lower numerical values indicate higher priorities).

The FIP Priority descriptor format shall be as specified in table 30.

Table 30 – FIP Priority descriptor format

Bit / Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Type = 01h								Length = 01h								Reserved								Priority							

Priority: the Priority value associated with the sending FCF-MAC.

7.8.6.3.3 FIP MAC address descriptor

The FIP MAC address descriptor is used in FIP operations as specified in table 45.

The FIP MAC address descriptor format shall be as specified in table 31.

Table 31 – FIP MAC address descriptor format

Bit / Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Type = 02h								Length = 02h								(MSB)															
1	MAC address																														(LSB)	

MAC address: the MAC address contained in the descriptor. Valid MAC addresses are unicast addresses.

7.8.6.3.4 FIP FC-MAP descriptor

The FIP FC-MAP descriptor is used in FIP operations as specified in table 45.

The FIP FC-MAP descriptor format shall be as specified in table 32.

Table 32 – FIP FC-MAP descriptor format

Bit / Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Type = 03h								Length = 02h								Reserved															
1	Reserved								(MSB)								FC-MAP														(LSB)	

FC-MAP: the value to be used as the most significant 24 bits in FPMAs (see 7.6).

7.8.6.3.5 FIP Name_Identifier descriptor

The FIP Name_Identifier descriptor is used in FIP operations as specified in table 45.

The FIP Name_Identifier descriptor format shall be as specified in table 33.

Table 33 – FIP Name_Identifier descriptor format

Word \ Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Type = 04h								Length = 03h								Reserved															
1	(MSB)								Name_Identifier																							
2																															(LSB)	

Name_Identifier: the Name_Identifier (see FC-FS-3) contained in the descriptor.

7.8.6.3.6 FIP Fabric descriptor

The FIP Fabric descriptor is used in FIP operations as specified in table 45.

The FIP Fabric descriptor format shall be as specified in table 34.

Table 34 – FIP Fabric descriptor format

Word \ Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Type = 05h								Length = 04h								VF_ID															
1	Reserved								(MSB)								FC-MAP															(LSB)
2	(MSB)								Fabric_Name																							
3																																(LSB)

VF_ID: the VF_ID (see see FC-FS-3) associated with the Fabric, if any.

FC-MAP: the value to be used as the most significant 24 bits in FPMAs (see 7.6).

Fabric_Name: the Fabric_Name (see FC-FS-3) identifying the Fabric.

7.8.6.3.7 FIP Max FCoE Size descriptor

The FIP Max FCoE Size descriptor is used in FIP operations as specified in table 45.

The FIP Max FCoE Size descriptor format shall be as specified in table 35.

Table 35 – FIP Max FCoE Size descriptor format

Word \ Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Type = 06h								Length = 01h								Max_FCoE_Size															

Max_FCoE_Size: the size in bytes that the FIP PDU (see table 24) in a solicited unicast Discovery Advertisement is requested to be extended to.

7.8.6.3.8 FIP FLOGI descriptor

The FIP FLOGI descriptor is used in FIP operations as specified in table 45.

The FIP FLOGI descriptor format shall be as specified in table 36

Table 36 – FIP FLOGI descriptor format

Bit / Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Type = 07h								Length								Reserved															
1	(MSB) FLOGI Request or FLOGI LS_ACC/LS_RJT																															
n																																(LSB)

Length: shall be set to 36 for a FLOGI Request and FLOGI LS_ACC, or to 9 for a FLOGI LS_RJT.

FLOGI Request or FLOGI LS_ACC/LS_RJT: an encapsulated FLOGI Request, FLOGI LS_ACC, or FLOGI LS_RJT shall be a complete Fibre Channel frame content (see FC-FS-3) with a Fibre Channel Frame_Header and an ELS payload but without the CRC field. In an FLOGI Request or FLOGI LS_ACC, the Payload bit shall be set to zero (see FC-LS-2).

7.8.6.3.9 FIP NPIV FDISC descriptor

The FIP NPIV FDISC descriptor is used in FIP operations as specified in table 45.

The FIP NPIV FDISC descriptor format shall be as specified in table 37

Table 37 – FIP NPIV FDISC descriptor format

Bit / Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Type = 08h								Length								Reserved															
1	(MSB) NPIV FDISC Request or NPIV FDISC LS_ACC/LS_RJT																															
n																																(LSB)

Length: shall be set to 36 for an FDISC Request and FDISC LS_ACC, or to 9 for an FDISC LS_RJT.

NPIV FDISC Request or NPIV FDISC LS_ACC/LS_RJT: an encapsulated FDISC Request, FDISC LS_ACC, or FLOGI LS_RJT shall be a complete Fibre Channel frame content (see FC-FS-3) with a Fibre Channel Frame_Header and an ELS payload but without the CRC field. In an FLOGI Request or FLOGI LS_ACC, the Payload bit shall be set to zero (see FC-LS-2).

7.8.6.3.10 FIP LOGO descriptor

The FIP LOGO descriptor is used in FIP operations as specified in table 45.

The FIP LOGO descriptor format shall be as specified in table 38

Table 38 – FIP LOGO descriptor format

Bit / Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Type = 09h								Length								Reserved															
1	(MSB) LOGO Request or LOGO LS_ACC/LS_RJT																															
n																																(LSB)

Length: shall be set to 11 for a LOGO Request, 8 for a LOGO LS_ACC, or to 9 for a LOGO LS_RJT.

LOGO Request or LOGO LS_ACC/LS_RJT: an encapsulated LOGO Request, LOGO LS_ACC, or LOGO LS_RJT shall be a complete Fibre Channel frame content (see FC-FS-3) with a Fibre Channel Frame_Header and an ELS payload but without the CRC field (see FC-LS-2).

7.8.6.3.11 FIP ELP descriptor

The FIP ELP descriptor is used in FIP operations as specified in table 45.

The FIP ELP descriptor format shall be as specified in table 39.

Table 39 – FIP ELP descriptor format

Bit / Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Type = 0Ah								Length								Reserved															
1	(MSB)								ELP Request or ELP SW_ACC/SW_RJT																							
n																																(LSB)

Length: shall be set to 33 for an ELP Request and ELP SW_ACC, or to 9 for an ELP SW_RJT.

ELP Request or ELP SW_ACC/SW_RJT: an encapsulated ELP Request, ELP SW_ACC, or ELP SW_RJT shall be a complete Fibre Channel frame content (see FC-FS-3) with a Fibre Channel Frame_Header and an SW_ILS payload but without the CRC field (see FC-SW-5).

7.8.6.3.12 FIP Vx_Port Identification descriptor

The FIP Vx_Port Identification descriptor is used in FIP operations as specified in table 45.

The FIP Vx_Port Identification descriptor format shall be as specified in table 40.

Table 40 – FIP Vx_Port Identification descriptor format

Bit / Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Type = 0Bh								Length = 05h								(MSB)															
1	MAC address																														(LSB)	
2	Reserved								(MSB)								Address Identifier														(LSB)	
3	(MSB)								Port_Name																							
4																																(LSB)

MAC address: the MAC address associated with the referred VN_Port or VE_Port. Valid MAC addresses are unicast addresses.

Address Identifier: the address identifier associated with the referred VN_Port or the value FFFFFDh for a VE_Port.

Port_Name: the N_Port_Name of the referred VN_Port or the E_Port_Name of the referred VE_Port.

7.8.6.3.13 FIP FKA_ADV_Period descriptor

The FIP FKA_ADV_Period descriptor is used in FIP operations as specified in table 45.

The FIP FKA_ADV_Period descriptor format shall be as specified in table 41.

Table 41 – FIP FKA_ADV_Period descriptor format

Bit / Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Type = 0Ch								Length = 02h								Reserved															D
1	FKA_ADV_PERIOD																															

D: the value of the D bit shall be administratively configurable on FCFs. The D bit shall be set to zero unless administratively set to one. VE_Port capable FCF-MACs shall ignore the value of the D bit provided in received Discovery Advertisements. ENode MACs shall process the value of the D bit provided in received Discovery Advertisements.

When the D bit is set to zero, the receiving ENode MAC shall verify periodic reception of Discovery Advertisements and shall transmit periodic ENode FIP Keep Alive and VN_Port FIP Keep Alive frames as specified in 7.8.5.2. The VF_Port capable FCF-MAC shall verify periodic reception of ENode FIP Keep Alive and VN_Port FIP Keep Alive frames as specified in 7.8.5.2.

When the D bit is set to one, the receiving ENode MAC may verify periodic reception of Discovery Advertisements and should not transmit periodic ENode FIP Keep Alive and VN_Port FIP Keep Alive frames as specified in 7.8.5.2. The VF_Port capable FCF-MAC shall not verify periodic reception of ENode FIP Keep Alive and VN_Port FIP Keep Alive frames as specified in 7.8.5.2 and should discard possible received ENode FIP Keep Alive and VN_Port FIP Keep Alive frames.

FKA_ADV_PERIOD: the value of the advertised FKA_ADV_PERIOD (see table 47). See table 47 for the range of valid values for FKA_ADV_PERIOD.

7.8.6.3.14 FIP Vendor_ID descriptor

The FIP Vendor_ID descriptor is used in FIP operations as specified in table 45.

The FIP Vendor_ID descriptor format shall be as specified in table 42.

Table 42 – FIP Vendor_ID descriptor format

Bit / Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Type = 0Dh								Length = 03h								Reserved															
1	(MSB)								Vendor_ID																							
2																															(LSB)	

Vendor_ID: the vendor's Vendor_ID value.

7.8.6.3.15 FIP VLAN descriptor

The FIP VLAN descriptor is used in in FIP operations as specified in table 45.

The FIP VLAN descriptor format shall be as specified in table 43

Table 43 – FIP VLAN descriptor format

Bit / Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Type = 0Eh								Length = 01h								Reserved				FCoE VID											

FCoE VID: the VLAN ID of a VLAN where FCoE services may be available. The range of valid values for VLAN IDs is 001h to FFEh.

7.8.6.3.16 FIP Vendor Specific descriptors

FIP Vendor Specific descriptors are non-critical and may be used in any FIP frame. An FC-BB_E device shall not require the use of any FIP Vendor Specific descriptor in order to operate in accordance with this standard.

The FIP Vendor Specific descriptor format is specified in table 44.

Table 44 – FIP Vendor Specific descriptor format

Bit / Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Type								Length								Reserved															
1	(MSB)								Vendor_ID																							
2																															(LSB)	
3	(MSB)								Vendor Specific information																							
n																															(LSB)	

Type: the FIP Vendor Specific descriptors are identified by a type value in the range 241 to 254, inclusive.

Length: shall be set to the length in words of the descriptor.

Vendor_ID: the vendor's Vendor_ID value.

Vendor Specific Information: defined by the vendor.

7.8.7 FIP operations

7.8.7.1 FIP operations overview

Table 45 specifies the FIP descriptors required in each FIP operation and the recommended order in which they should be encapsulated by a transmitting FCoE Controller. In certain cases, as indicated, strict ordering is required. A receiving FCoE Controller shall process unknown descriptors according to the criticality of the FIP descriptor (see 7.8.6.3.1). Unless otherwise specified (e.g., for a FIP FLOGI Request), a receiving FCoE Controller shall be able to process the FIP descriptors in any order.

NOTE 28 – The ability to process FIP descriptors in any order is to provide flexibility for future protocol extensions,

A FIP operation shall contain the expected critical descriptors (see table 45) and may contain additional non-critical descriptors. If some critical descriptors are missing or unexpected, the FIP operation shall be discarded and it should be reported in a vendor specific manner.

Table 45 – FIP operation descriptors and order

FIP Operation	FIP Protocol Code/Subcode[a]	Originator	Expected Descriptors and Order
Discovery Solicitation (see 7.8.7.2.1)	0001h/01h	ENode	1) MAC address 2) Name_Identifier 3) Max FCoE Size
Discovery Solicitation (see 7.8.7.2.2)	0001h/01h	FCF	1) MAC address 2) FC-MAP 3) Name_Identifier 4) Max FCoE Size
Discovery Advertisement (see 7.8.7.3)	0001h/02h	FCF	1) Priority 2) MAC address 3) Name_Identifier 4) Fabric 5) FKA_ADV_Period
FIP FLOGI Request[b] (see 7.8.7.4.2)	0002h/01h	ENode	1) FLOGI 2) MAC address
FIP FLOGI LS_ACC[b] (see 7.8.7.4.2)	0002h/02h	FCF	1) FLOGI 2) MAC address
FIP FLOGI LS_RJT[b] (see 7.8.7.4.2)	0002h/02h	FCF	1) FLOGI
FIP NPIV FDISC Request[b] (see 7.8.7.4.2)	0002h/01h	ENode	1) NPIV FDISC 2) MAC address
FIP NPIV FDISC LS_ACC[b] (see 7.8.7.4.2)	0002h/02h	FCF	1) NPIV FDISC 2) MAC address
FIP NPIV FDISC LS_RJT[b] (see 7.8.7.4.2)	0002h/02h	FCF	1) NPIV FDISC

a) Virtual Link instantiation requests are differentiated by the contained descriptors.
b) Strict ordering of the FIP descriptors is required in transmission. In this way the encapsulated ELS or SW_ILS results at an offset in the FIP PDU equal to the offset it would have if it was encapsulated in an FCoE PDU. A receiving FCoE Controller is not required to be able to process these FIP operations in any order other than that specified here.
c) FCFs are allowed to generate FIP LOGO, however a FIP Clear Virtual Link frame is the recommended method for an FCF to de-instantiate a Virtual Link, except for the specific cases where LOGO is required (see FC-SP).
d) The Vx_Port Identification descriptor is present only in VN_Port FIP Keep Alive frames, it is not present in ENode FIP Keep Alive frames.
e) A FIP Clear Virtual Links frame intended to de-instantiate VN_Port to VF_Port Virtual Links contains zero or more Vx_Port Identification descriptors. A FIP Clear Virtual Links frame intended to de-instantiate a VE_Port to VE_Port Virtual Link contains one Vx_Port Identification descriptor.
f) The Name_Identifier descriptor is optional in FIP VLAN Request frames (i.e., the Name_Identifier descriptor may be not present).

Table 45 – FIP operation descriptors and order (Continued)

FIP Operation	FIP Protocol Code/Subcode[a]	Originator	Expected Descriptors and Order
FIP Fabric LOGO[b] (see 7.8.7.4.3)	0002h/01h	ENode[c]	1) LOGO 2) MAC address
FIP Fabric LOGO LS_ACC[b] (see 7.8.7.4.3)	0002h/02h	FCF[c]	1) LOGO 2) MAC address
FIP Fabric LOGO LS_RJT[b] (see 7.8.7.4.3)	0002h/02h	FCF[c]	1) LOGO
FIP ELP Request[b] (see 7.8.7.4.4)	0002h/01h	FCF	1) ELP 2) MAC address
FIP ELP SW_ACC[b] (see 7.8.7.4.4)	0002h/02h	FCF	1) ELP 2) MAC address
FIP ELP SW_RJT[b] (see 7.8.7.4.4)	0002h/02h	FCF	1) ELP
FIP Keep Alive (see 7.8.7.5)	0003h/01h	ENode	1) MAC address 2) Vx_Port Identification[d]
FIP Clear Virtual Links (see 7.8.7.6	0003h/02h	FCF	1) MAC address 2) Name_Identifier 3) Vx_Port Identification(s)[e]
FIP VLAN Request (see 7.8.7.7)	0004h/01h	ENode or FCF	1) MAC address 2) Name_Identifier[f]
FIP VLAN Notification (see 7.8.7.8)	0004h/02h	FCF	1) MAC address 2) VLAN(s)
FIP Vendor Specific (see 7.8.7.9)	FFF8h to FFFEh / 00h to FFh	ENode or FCF	1) Vendor_ID 2) Descriptor(s)

a) Virtual Link instantiation requests are differentiated by the contained descriptors.
b) Strict ordering of the FIP descriptors is required in transmission. In this way the encapsulated ELS or SW_ILS results at an offset in the FIP PDU equal to the offset it would have if it was encapsulated in an FCoE PDU. A receiving FCoE Controller is not required to be able to process these FIP operations in any order other than that specified here.
c) FCFs are allowed to generate FIP LOGO, however a FIP Clear Virtual Link frame is the recommended method for an FCF to de-instantiate a Virtual Link, except for the specific cases where LOGO is required (see FC-SP).
d) The Vx_Port Identification descriptor is present only in VN_Port FIP Keep Alive frames, it is not present in ENode FIP Keep Alive frames.
e) A FIP Clear Virtual Links frame intended to de-instantiate VN_Port to VF_Port Virtual Links contains zero or more Vx_Port Identification descriptors. A FIP Clear Virtual Links frame intended to de-instantiate a VE_Port to VE_Port Virtual Link contains one Vx_Port Identification descriptor.
f) The Name_Identifier descriptor is optional in FIP VLAN Request frames (i.e., the Name_Identifier descriptor may be not present).

7.8.7.2 FIP Discovery Solicitation

7.8.7.2.1 ENode FIP Discovery Solicitation

As specified in table 45, a Discovery Solicitation operation originated by the FCoE Controller of an ENode MAC contains a MAC address descriptor (see 7.8.6.3.3), a Name_Identifier descriptor (see 7.8.6.3.5), and a Max FCoE Size descriptor (see 7.8.6.3.7).

A Discovery Solicitation frame may be unicast (i.e., addressed to a specific FCF-MAC) or multicast (i.e., addressed to the All-FCF-MACs group address).

The MAC address field in the MAC address descriptor shall be set to the MAC address to use for subsequent solicited Discovery Advertisements from VF_Port capable FCF-MACs.

The Name_Identifier field in the Name_Identifier descriptor shall be set to the Node_Name of the ENode or to zero.

NOTE 29 – The Name_Identifer field may be set to zero if the Node_Name is ambiguous or not yet available when the Discovery Solicitation is transmitted.

The Max_FCoE_Size field in the Max FCoE Size descriptor shall be set to the maximum FCoE PDU size the ENode MAC intends to use for FCoE traffic. The Max_FCoE_Size value shall be specified as the number of octets starting with and including Version field, up to and including the Reserved field following the EOF field (see table 21).

7.8.7.2.2 FCF FIP Discovery Solicitation

As specified in table 45, a Discovery Solicitation operation originated by the FCoE Controller of a VE_Port capable FCF-MAC contains a MAC address descriptor (see 7.8.6.3.3), an FC-MAP descriptor (see 7.8.6.3.4), a Name_Identifier descriptor (see 7.8.6.3.5), and a Max FCoE Size descriptor (see 7.8.6.3.7).

A Discovery Solicitation frame may be unicast (i.e., addressed to a specific FCF-MAC) or multicast (i.e., addressed to the All-FCF-MACs group address).

The MAC address field in the MAC address descriptor shall be set to the MAC address to use for subsequent solicited Discovery Advertisements from VE_Port capable FCF-MACs.

For FCF-MACs that support FPMA, the FC-MAP field in the FC-MAP descriptor shall be set to the FC-MAP value the FCF-MAC is using. If the FC-MAP value is not administratively configured, then the FC-MAP value shall be set to DEFAULT_FC-MAP (see table 47).

For FCF-MACs that only support SPMA, the FC-MAP field in the FC-MAP descriptor shall be set to zero.

The Name_Identifier field in the Name_Identifier descriptor shall be set to the Switch_Name of the FCF.

The Max_FCoE_Size field in the Max FCoE Size descriptor shall be set to the maximum FCoE frame size the VE_Port capable FCF-MAC intends to use for FCoE traffic. The Max_FCoE_Size value shall be specified as the number of octets starting with and including the Version field, up to and including the Reserved field following the EOF field (see table 21).

7.8.7.3 FIP Discovery Advertisements

As specified in table 45, a Discovery Advertisement operation contains a Priority descriptor (see 7.8.6.3.2), a MAC address descriptor (see 7.8.6.3.3), a Name_Identifier descriptor (see 7.8.6.3.5), a Fabric descriptor (see 7.8.6.3.6), and a FKA_ADV_Period descriptor (see 7.8.6.3.13).

When a Discovery Advertisement frame is solicited, it shall be unicast (i.e., addressed to a specific ENode MAC or FCF-MAC address). When a Discovery Advertisement frame is unsolicited, it shall be multicast (i.e., addressed to the All-ENode-MACs or to the All-FCF-MACs group addresses).

The Priority field in the Priority descriptor shall be set to the value the originating FCF-MAC is using. If the priority value is not administratively configured, then the priority value shall be set to DEFAULT_FIP_PRIORITY (see table 47).

The MAC address field in the MAC address descriptor shall be set to the originating FCF-MAC address.

The Name_Identifier field in the Name_Identifier descriptor shall be set to the Switch_Name of the originating FCF.

Discovery Advertisements shall only contain a single Fabric descriptor. All Discovery Advertisements from an FCF in a VLAN shall contain the same single Fabric descriptor. The VF_ID field in the Fabric descriptor shall be set to the VF_ID identifying the advertised FC Fabric. If a VF_ID is not defined for the advertised FC Fabric, the VF_ID field shall be set to zero. For FCFs that support FPMA, the FC-MAP field in the Fabric descriptor shall be set to the FC-MAP value the FCF is using. If the FC-MAP value is not administratively configured, then the FC-MAP value shall be set to DEFAULT_FC-MAP (see table 47). For FCFs that only support SPMA, the FC-MAP field in the Fabric descriptor shall be set to zero. The Fabric_Name field in the Fabric descriptor shall be set to the Fabric_Name for the originating FCF.

The FKA_ADV_PERIOD field in the FKA_ADV_Period descriptor shall be set to the FKA_ADV_PERIOD value the FCF is advertising (see table 47).

The FIP_Pad field shall be used to extend the FIP PDU (see table 24) to have a length that matches the Max_FCoE_Size field value in the Max FCoE Size descriptor in the Discovery Solicitation to which the Discovery Advertisement is responding. The FIP_Pad field value shall be set to zero and not checked in reception. For an unsolicited Discovery Advertisement, the FIP_Pad field shall be of zero length (i.e., not present).

7.8.7.4 FIP Virtual Link Instantiation Requests and Replies

7.8.7.4.1 FIP Virtual Link Instantiation Requests and Replies overview

FIP Virtual Link Instantiation Requests and Replies encapsulates an ELS or an SW_ILS. The encapsulated ELS or SW_ILS shall be a single-frame Sequence. FIP Virtual Link Instantiation Requests and Replies are used to perform:

a) Fabric login between ENode MACs and VF_Port capable FCF-MACs (see 7.8.7.4.2);
b) Fabric logout between ENode MACs and VF_Port capable FCF-MACs (see 7.8.7.4.3); and
c) Exchange Link Parameters between VE_Port capable FCF-MACs (see 7.8.7.4.4).

7.8.7.4.2 Fabric login

As specified in table 45:

a) a FIP FLOGI Request operation contains a FLOGI descriptor (see 7.8.6.3.8) and a MAC address descriptor (see 7.8.6.3.3);
b) a FIP FLOGI LS_ACC operation contains a FLOGI descriptor (see 7.8.6.3.8) and a MAC address descriptor (see 7.8.6.3.3);
c) a FIP FLOGI LS_RJT operation contains a FLOGI descriptor (see 7.8.6.3.8).
d) a FIP NPIV FDISC Request operation contains a NPIV FDISC descriptor (see 7.8.6.3.9) and a MAC address descriptor (see 7.8.6.3.3);
e) a FIP NPIV FDISC LS_ACC operation contains a NPIV FDISC descriptor (see 7.8.6.3.9) and a MAC address descriptor (see 7.8.6.3.3); and
f) a FIP NPIV FDISC LS_RJT operation contains a NPIV FDISC descriptor (see 7.8.6.3.9).

The FLOGI or NPIV FDISC descriptor shall be the first descriptor in the operation.

NOTE 30 – In this way the encapsulated Fibre Channel ELS results at an offset in the FIP PDU equal to the offset it would have if it was encapsulated in a FCoE PDU.

The FLOGI or NPIV FDISC descriptor shall contain:

a) a complete Fibre Channel frame content with a Fibre Channel Frame_Header (see FC-FS-3) and an FLOGI Request payload or an NPIV FDISC Request payload (see FC-LS-2) but without the CRC field (see FC-FS-3) for FIP FLOGI Request or FIP NPIV FDISC Request operations. The Payload bit in the FLOGI Request payload or NPIV FDISC Request payload shall be set to zero (see FC-LS-2);
b) a complete Fibre Channel frame content with a Fibre Channel Frame_Header (see FC-FS-3) and an FLOGI LS_ACC payload or an NPIV FDISC LS_ACC payload (see FC-LS-2) but without the CRC field (see FC-FS-3) for FIP FLOGI LS_ACC or FIP NPIV FDISC LS_ACC operations. The Payload bit in the FLOGI LS_ACC payload shall be set to zero (see FC-LS-2); or
c) a complete Fibre Channel frame content with a Fibre Channel Frame_Header (see FC-FS-3) and an FLOGI LS_RJT payload or an NPIV FDISC LS_RJT payload (see FC-LS-2) but without the CRC field (see FC-FS-3) for FIP FLOGI LS_RJT or FIP NPIV FDISC LS_RJT operations.

The MAC address field in the MAC address descriptor of a FIP FLOGI Request operation or a FIP NPIV FDISC Request operation shall contain:

a) the proposed MAC address to use as VN_Port MAC address if the ENode is requesting to use SPMA (see table 27);
b) all zeroes to indicate no MAC address is proposed if the ENode is requesting to use FPMA (see table 27); or
c) the proposed MAC address to use as VN_Port MAC address if the ENode supports both SPMA and FPMA and leaves the decision of which addressing scheme to use to the FCF (i.e., if both the FP and SP bits are set to one, see table 27).

The MAC address field in the MAC address descriptor of a FIP FLOGI LS_ACC operation or a FIP NPIV FDISC LS_ACC operation shall contain the MAC address that the FCF granted for use as VN_Port MAC address. The FP and SP bits shall be set as shown in table 28. If the FCF granted an SPMA, the granted MAC address shall be the same as the one carried in the MAC address descriptor of the corresponding FIP FLOGI Request operation or FIP NPIV FDISC Request operation. If the FCF granted an FPMA, the granted MAC address shall be a properly formed FPMA (see 7.6). An ENode shall verify that a granted FPMA address is properly formed.

A FIP FLOGI or FIP NPIV FDISC operation shall be processed respectively as the FLOGI or FDISC ELS with S_ID = 000000h specified in FC-LS-2, ignoring the buffer-to-buffer flow control parameters. If no response to a FIP FLOGI Request or FIP NPIV FDISC Request is received within the ELS

timeout value specified in FC-LS-2, the Exchange resources may be reused and the ABTS protocol (see FC-FS-3) shall not be used.

A successful FIP FLOGI operation instantiates a VF_Port, a VN_Port, and a Virtual Link between them. Subsequent FIP NPIV FDISC operations from the same ENode MAC Address as the FIP FLOGI operation associate additional VN_Ports to the same VF_Port that was instantiated by the FIP FLOGI operation. Subsequent FIP NPIV FDISC operations from the same ENode MAC address as the FIP FLOGI operation should request the same MAC address type (i.e., FPMA or SPMA) as the FIP FLOGI operation. A subsequent FIP FLOGI operation from the same ENode MAC Address is equivalent to an implicit logout of all the VN_Ports followed by an FLOGI, as specified in FC-LS-2.

NOTE 31 – A duplicate MAC address may be a cause for an implicit logout.

FCFs shall reject FIP FLOGI Requests and FIP NPIV FDISC Requests for a single addressing mode (i.e., SPMA or FPMA) that is not supported by the FCFs. FCFs supporting FPMAs shall reject FIP FLOGI and FIP NPIV FDISC Requests with the SP bit set to one when the MAC address descriptor contains a proposed MAC address in which the 24 most significant bits match the FC-MAP in use by the FCFs. In addition, FCFs shall reject FIP FLOGI Requests and FIP NPIV FDISC Requests having:

a) both the SP bit and the FP bit set to zero;
b) the FP bit set to one, the SP bit set to zero, and the MAC address descriptor not set to zero; and
c) the SP bit set to one and the MAC address descriptor containing a MAC address that is not a unicast address.

Rejections of FIP FLOGI Requests and FIP NPIV FDISC Requests are performed with the LS_RJT Reason Codes and Reason Code Explanations specified in table 46.

Table 46 – FIP Fabric login rejections

Error Condition	Reason Code (see FC-LS-2)	Reason Code Explanation (see FC-LS-2)
The MAC addressing mode in the FIP FLOGI/FDISC Request is not supported.	FIP Error (i.e., 20h)	MAC addressing mode not supported (i.e., 60h).
The MAC address proposed in the MAC address descriptor of a FIP FLOGI/FDISC Request is incorrect for the requested addressing mode.	FIP Error (i.e., 20h)	Proposed MAC address incorrectly formed (i.e., 61h).

7.8.7.4.3 Fabric logout

As specified in table 45:

a) a FIP Fabric LOGO Request operation contains a LOGO descriptor (see 7.8.6.3.10) and a MAC address descriptor (see 7.8.6.3.3);
b) a FIP Fabric LOGO LS_ACC operation contains a LOGO descriptor (see 7.8.6.3.10) and a MAC address descriptor (see 7.8.6.3.3); and
c) a FIP Fabric LOGO LS_RJT operation contains a LOGO descriptor (see 7.8.6.3.10).

The LOGO descriptor shall be the first descriptor in the operation.

NOTE 32 – In this way the encapsulated Fibre Channel ELS results at an offset in the FIP PDU equal to the offset it would have if it was encapsulated in a FCoE PDU.

The LOGO descriptor shall contain:

a) a complete Fibre Channel frame content with a Fibre Channel Frame_Header (see FC-FS-3) and a Fabric LOGO Request payload (see FC-LS-2) but without the CRC field (see FC-FS-3) for FIP Fabric LOGO Request operations;
b) a complete Fibre Channel frame content with a Fibre Channel Frame_Header (see FC-FS-3) and a Fabric LOGO LS_ACC payload (see FC-LS-2) but without the CRC field (see FC-FS-3) for FIP Fabric LOGO LS_ACC operations; or
c) a complete Fibre Channel frame content with a Fibre Channel Frame_Header (see FC-FS-3) and a Fabric LOGO LS_RJT payload (see FC-LS-2) but without the CRC field (see FC-FS-3) for FIP Fabric LOGO LS_RJT operations.

The MAC address field in the MAC address descriptor of a FIP Fabric LOGO Request and a FIP Fabric LOGO LS_ACC operation shall be set to the MAC address assigned to the VN_Port that is being logged out.

A FIP Fabric LOGO operation shall be processed as the Fabric LOGO ELS specified in FC-LS-2. If no response to a FIP Fabric LOGO Request is received within the ELS timeout value specified in FC-LS-2, the Exchange resources may be reused and the ABTS protocol (see FC-FS-3) shall not be used.

7.8.7.4.4 Exchange Link Parameters

As specified in table 45:

a) a FIP ELP Request operation contains a ELP descriptor (see 7.8.6.3.11) and a MAC address descriptor (see 7.8.6.3.3);
b) a FIP ELP SW_ACC operation contains a ELP descriptor (see 7.8.6.3.11) and a MAC address descriptor (see 7.8.6.3.3); and
c) a FIP ELP SW_RJT operation contains a ELP descriptor (see 7.8.6.3.11).

The ELP descriptor shall be the first descriptor in the operation.

NOTE 33 – In this way the encapsulated Fibre Channel SW_ILS results at an offset in the FIP PDU equal to the offset it would have if it was encapsulated in a FCoE PDU.

The ELP descriptor shall contain:

a) a complete Fibre Channel frame content with a Fibre Channel Frame_Header (see FC-FS-3) and a ELP Request payload specifying R_RDY Flow Control (see FC-SW-5) but without the CRC field (see FC-FS-3) for FIP ELP Request operations;
b) a complete Fibre Channel frame content with a Fibre Channel Frame_Header (see FC-FS-3) and a ELP SW_ACC payload (see FC-SW-5) but without the CRC field (see FC-FS-3) for FIP ELP SW_ACC operations; or
c) a complete Fibre Channel frame content with a Fibre Channel Frame_Header (see FC-FS-3) and a ELP SW_RJT payload (see FC-SW-5) but without the CRC field (see FC-FS-3) for FIP ELP SW_RJT operations.

The MAC address field in the MAC address descriptor of a FIP ELP Request and a FIP ELP SW_ACC operation shall be set to the MAC address of the destination FCF-MAC.

A FIP ELP operation shall be processed as the ELP SW_ILS specified in FC-SW-5, ignoring the buffer-to-buffer flow control parameters.

7.8.7.5 FIP Keep Alive

As shown in table 45, a FIP Keep Alive operation contains a MAC address descriptor (see 7.8.6.3.3) and zero or one Vx_Port Identification descriptor (see 7.8.6.3.12).

ENode FIP Keep Alive operations (see 7.8.5.1) contains only a MAC address descriptor. VN_Port FIP Keep Alive operations (see 7.8.5.1) contain a MAC address descriptor and a Vx_Port Identification descriptor.

ENode FIP Keep Alive frames shall have the originating ENode MAC address as the source address. The MAC address field in the MAC address descriptor shall be set to the originating ENode MAC address.

VN_Port FIP Keep Alive frames shall have the VN_Port MAC address as the source address. The MAC address field in the MAC address descriptor shall be set to the originating ENode MAC address. In the Vx_Port Identification descriptor, the MAC address field shall be set to the VN_Port MAC address, the Address Identifier field shall be set to the VN_Port N_Port_ID, and the Port_Name field shall be set to the VN_Port N_Port_Name.

7.8.7.6 FIP Clear Virtual Links

7.8.7.6.1 FIP Clear Virtual Links to an ENode

The FCoE Controller of a VF_Port capable FCF-MAC may de-instantiate one or more VN_Port to VF_Port Virtual Links by transmitting a FIP Clear Virtual Links frame to an ENode MAC. As specified in table 45, this FIP Clear Virtual Links frame shall contain one MAC address descriptor (see 7.8.6.3.3), one Name_Identifier descriptor (see 7.8.6.3.5), and a list of Vx_Port Identification descriptors (see 7.8.6.3.12), one for each VN_Port the Virtual Link with it is requested to be de-instantiated.

The MAC address field in the MAC address descriptor shall be set to the FCF-MAC address of the originating FCF-MAC. The Name_Identifier field in the Name_Identifier descriptor shall be set to the Switch_Name of the originating FCF. For each Vx_Port Identification descriptor, the MAC address field shall be set to the VN_Port MAC address, the Address Identifier field shall be set to the VN_Port N_Port_ID, and the Port_Name field shall be set to the VN_Port N_Port_Name. The FCoE Controller of a receiving ENode MAC shall ignore a Vx_Port Identification descriptor that does not match any of its instantiated VN_Ports.

7.8.7.6.2 FIP Clear Virtual Links to an FCF

The FCoE Controller for a VE_Port capable FCF-MAC may de-instantiate a VE_Port to VE_Port Virtual Link by transmitting a FIP Clear Virtual Links frame to a VE_Port capable FCF-MAC. As specified in table 45, this FIP Clear Virtual Links frame shall contain one MAC address descriptor (see 7.8.6.3.3), one Name_Identifier descriptor (see 7.8.6.3.5), and one Vx_Port Identification descriptor (see 7.8.6.3.12).

The MAC address field in the MAC address descriptor shall be set to the FCF-MAC address of the originating FCF-MAC. The Name_Identifier field in the Name_Identifier descriptor shall be set to the

Switch_Name of the originating FCF. In the Vx_Port Identification descriptor, the MAC address field shall be set to the remote FCF-MAC address, the Address Identifier field shall be set to FFFFFDh, and the Port_Name field shall be set to the remote E_Port_Name.

7.8.7.7 FIP VLAN Request

As specified in table 45, a FIP VLAN Request operation contains a MAC address descriptor and optionally a Name_Identifier descriptor (see 7.8.6.3.3). A FIP VLAN Request frame may be generated by an ENode MAC or by an FCF-MAC.

When generated by an ENode MAC, the FIP VLAN Request frame shall have the F flag set to zero and the MAC address field in the MAC address descriptor shall be set to the originating ENode MAC address. If a Name_Identifier descriptor is present, the Name_Identifier field should be set to the Node_Name of the originating ENode.

When generated by an FCF-MAC, the FIP VLAN Request frame shall have the F flag set to one and the MAC address field in the MAC address descriptor shall be set to the originating FCF-MAC address. If a Name_Identifier descriptor is present, the Name_Identifier field should be set to the Switch_Name of the originating FCF.

7.8.7.8 FIP VLAN Notification

As specified in table 45, a FIP VLAN Notification operation contains a MAC address descriptor (see 7.8.6.3.3) and one or more VLAN descriptors (see 7.8.6.3.15). A FIP VLAN Notification frame is generated by an FCF-MAC.

The MAC address field in the MAC address descriptor shall be set to the originating FCF-MAC address. The FCoE VID field of each of the FIP VLAN descriptors shall be set to a VID over which the FCF-MAC is offering FC-BB_E services.

7.8.7.9 FIP Vendor Specific frames

FIP Vendor Specific frames may be transmitted by both ENodes and FCFs. As specified in table 45, a FIP Vendor Specific frame shall include a Vendor_ID descriptor (see 7.8.6.3.14) as the first descriptor, followed by one or more additional descriptors. An unknown received FIP Vendor Specific frame shall be discarded. An FC-BB_E device shall not require the use of any FIP Vendor Specific frame in order to operate in accordance with this standard.

7.9 Timers and constants

FC-BB_E timers and constants are specified in table 47.

Table 47 – FC-BB_E timers and constants

Timer/Constant	Value	Description	Reference
FIP_TYPE	8914h	The value specified in the Ethernet Type field for a FIP PDU.	7.8.6.1
FCoE_TYPE	8906h	The value specified in the Ethernet Type field for an FCoE PDU.	7.7
FIP_FRAME_VER	0001b	The value specified in the Version field for a FIP PDU.	7.8.6.1
FCoE_FRAME_VER	0000b	The value specified in the Version field for an FCoE PDU.	7.7
All-FCoE-MACs	01-10-18-01-00-00	The group address for all FCoE devices.	7.8.1
All-ENode-MACs	01-10-18-01-00-01	The group address for all ENodes.	7.8.1
All-FCF-MACs	01-10-18-01-00-02	The group address for all FCFs.	7.8.1
DEFAULT_FIP_PRIORITY	128	The default value specified in the FIP Priority descriptor.	7.8.6.3.2
DEFAULT_FC-MAP	0EFC00h	The default value for the FC-MAP field in a FIP FC-MAP descriptor.	7.8.6.3.4
ADV_TOV	2	The interval in seconds within which solicited Discovery Advertisements are transmitted, if the FCF chooses so, upon reception of a Discovery Solicitation.	7.8.3
FKA_ADV_PERIOD	-	The interval in milliseconds between periodic Discovery Advertisements and ENodes FIP Keep Alive frames. The default value is 8 000. Valid values are in the range 250 to 90 000.	7.8.3, 7.8.5
FKA_VN_PERIOD	90[a]	The interval in seconds between periodic VN_Port FIP Keep Alive frames.	7.8.5

a) This value has been chosen as appropriate to keep the forwarding tables of intermediate Lossless Ethernet bridges updated.

7.10 FC-BB_E Link Error Status Block (LESB) definition

FC-FS-3 specifies a Link Error Status Block (LESB) to monitor link error statistics that are useful for problem determination in Fibre Channel topologies. The LESB may be obtained from an FC-BB_E VN_Port using the Read Link Error Status Block (RLS) ELS request (see FC-LS-2).

An FC-BB_E VN_Port or VF_Port that supports the LESB with the FC-BB_E format (see table 21) shall provide this LESB format in response to an RLS ELS request. If an FC-BB_E VN_Port or VF_Port that is the designated FC_Port of an RLS request sequence does not support any of the fields specified in table 48, the recipient of the RLS request sequence shall reply to the RLS request with an LS_RJT specifying a reason code of "Unable to perform command request" (i.e., 09h) and should respond with a reason code explanation of "Request not supported" (i.e., 2Ch) (see FC-LS-2). A subset of the counters in the LESB may be supported and any unsupported counters shall be set to zero.

Table 48 specifies the format for the FC-BB_E LESB that shall be used in response to an RLS request by an FC-BB_E VN_Port or VF_Port.

Table 48 – FC-BB_E Link Error Status Block format

Bit / Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Link Failure Count
1	Virtual Link Failure Count
2	Missing FIP Keep Alive or Discovery Advertisement Count
3	Symbol Error During Carrier Count
4	Errored Block Count
5	Frame Check Sequence Error Count

The Link Failure Count field indicates the number of link failures detected through detection of physical link transitions (i.e., the number of times that the aMediaAvailable attribute (see 802.3-2008 subclause 30.5.1.1.4) changes from the enumeration “available” to any other enumeration.

The Virtual Link Failure Count field indicates the number of virtual link failures detected by the Virtual Link maintenance protocol.

The Missing FIP Keep Alive or Discovery Advertisement field indicates the number of missing Virtual Link maintenance protocol frames. A missing Virtual Link maintenance protocol frame is detected after 1.5 times FKA_ADV_PERIOD since the reception of the last Virtual Link maintenance protocol frame. For an ENode, the Missing FIP Keep Alive or Discovery Advertisement field indicates the number of missing Discovery Advertisements. For a VF_Port, the Missing FIP Keep Alive or Discovery Advertisement field indicates the number of missing FIP Keep Alive frames from an ENode.

The Symbol Error During Carrier Count field indicates the number of reception errors at the PHY layer that occur during frame reception. The detection procedure is dependant on media and link speed (see 802.3-2008 subclause 30.3.2.1.5).

The Errored Block Count field indicates the cumulative count of the events counted by the eight-bit errored blocks counter (see 802.3-2008 subclause 45.2.3.12.4).

The Frame Check Sequence Error Count field indicates the number of Ethernet frames received that are an integral number of octets in length and do not pass the FCS check (see 802.3-2008 subclause 30.4.3.1.6).

7.11 Link Incidents definition

The Link Incident reporting procedure (see FC-LS-2) defines link incidents and corresponding incident codes that are based on the Fibre Channel physical layer. A definition of FC-BB_E Link Incidents and their respective Incident Code values (see table 49) are based on the IEEE 802.3 physical layer and the FC-BB_E Virtual Link maintenance protocol.

Bit-error rate thresholding (see FC-FS-3) defines error intervals as a time period during which Fibre Channel invalid Tranmission Words are recognized. For FC-BB_E devices an error interval is a time period during which one or more error blocks (see 802.3-2008 subclause 45.2.3.12.4) are recognized.

Table 49 specifies the Link Incidents for FC-BB_E that shall be used in a RLIR ELS request by an FC-BB_E VN_Port, VF_Port, or VE_Port.

Table 49 – FC-BB_E Link Incidents

Value	Meaning
00h	Reserved
01h	Implicit incident: A condition, caused by an event known to have occurred within the incident port, has been recognized by the incident port. The condition affects the attached link in such a way that it may cause a link incident to be recognized by the connected port.
02h	Bit-error-rate threshold exceeded: The incident port has detected that the Error Interval Count equals the Error Threshold (see FC-FS-3) where the Error Interval Count is based on errored blocks (see 802.3-2008 subclause 45.2.3.12.4).
03h	Link Failure - Loss-of-Signal: The aLoseMediaCounter has been incremented for entering an aMediaAvailable state indicating anything other than a remote fault (see 802.3-2008 subclause 30.5.1.1.4 and 802.3-2008 subclause 30.5.1.1.5).
04h	Link Failure - Remote fault: The aLoseMediaCounter has been incremented for an aMediaAvailable state being entered indicating a remote fault (see 802.3-2008 subclause 30.5.1.1.4 and 802.3-2008 subclause 30.5.1.1.5).
05h	Link Failure - Virtual Link failure: The incident port has detected a Virtual Link failure using the Virtual Link maintenance protocol.
06h to FFh	Reserved