A Comparison of Fibre Channel over Ethernet Proposals

07-336v1

Brocade Engineering Team
1 Introduction

Two proposals have been offered to T11 for consideration to provide for transport of Fibre Channel frames over Ethernet fabrics with certain defined characteristics (e.g. support of jumbograms). One is T11/07-303v0 FCoE - Specification (PropC), submitted by Nuova et. al. The other is T11/07-292v3 FCoE Text Proposal for FC-BB-5 (PropB), submitted by Brocade et. al. Not surprisingly, these proposals are similar in many respects. However, there are a number of significant differences.

This document attempts to summarize the differences between the two proposals in an objective manner. However, it must be noted that this document was developed by Brocade based on Brocade’s best understanding of PropC. We welcome all input from the developers of PropC to correct any misunderstandings that might be present in this document.

1.1 Introduction to Version 1 of this Document

Since the posting of Version 0 of this document, Silvano Gai of Nuova posted document T11/07-350v0, which contained many comments related to the original version of this document. The text of Version 1 has been updated where appropriate to respond to these comments, and all of his comments have been addressed in Appendix A.

In addition, the terminology in this document has been modified to remove reference to the term FCoCEE.

2 Basic Difference Between the Architectural Models

PropC proposes two architectural models, Type C and Type D:

- The Type C model contains a single Ethernet Bridge per VLAN. PropC seems to imply that the inclusion of an 802.1Q or 802.1D switch is required.

- The Type D model contains 2 or more Ethernet Bridges. A VLAN may be present on more than one of these bridges.

PropB allows, but does not require the presence of an Ethernet Bridge. In a deployment carrying FCoE traffic exclusively, there is no need for an Ethernet bridge. In this case, the PropB switch operates exactly like a FC-SW switch, except for the addition of the FCoE entity on each FCoE port that performs the encapsulation / de-encapsulation function.

The PropB approach is similar to the layering present in Ethernet and IP. In general, Ethernet is defined by IEEE and IP is defined by IETF. There is wide deployment of devices that support both Ethernet and IP (e.g. Layer 2 / Layer 3 switches), yet there is no standard that defines exactly how these two functions are combined in a single device.
This is left as an implementation decision. Recognizing that there are multiple valid approaches to combining Ethernet and FCoE (it is not limited to just those defined by PropC), PropB does not specify particular architectures of combined Ethernet / FCoE switches.

It might be argued that a type D FCoE switch with one bridge per port is equivalent to a PropB switch. This is close, but not quite true. A bridge behaves slightly different than a wire. For example, it may require configuration options, spanning tree support, and other management operations. Furthermore, it potentially imposes additional delays through the device. PropB is essentially equivalent to a type D FCoE switch with no bridges, i.e., the FCM ports are externally exposed.

In summary, PropB does not in any way prohibit PropC type C and type D architectures. It simply does not mandate them and therefore enables other valid and useful architectures.

**Observations / Questions:**

- Is there a need for defining specific types of forwarding models, e.g., one for directly connected deployment and another for in-directly connected deployment? Although PropC provides two different models, PropC seems to discourage usage of the Type C FCF model. For example, in section 1.3.1 of T11/07-303v0, it is pointed out that the direct communication provided by Type C is undesirable. On the other hand, in T11/07-350v0, the statement is made that Type C may well be favored for IO consolidation (see the comment related to the first bullet in section 2).

- PropB supports both the Type C and Type D models, as well as others since it does not restrict the methods by which one may interconnect Ethernet and FCoE switches in a single box.

- PropB doesn’t require nor prohibit the inclusion of an Ethernet Bridge with the FCoE switch. The PropB model does not prohibit the deployments illustrated in the PropC proposal nor does it prohibit other useful architectures. This is similar to the industry practice with Ethernet / IP switches.

- For reference, below is an illustration of the PropB model using PropC terminology:
• In this alternative model each FCoE port has an FCM and each FCM has a universal MAC. In this way the Ethernet addressing is constrained to one simple form.

• In most deployments one will find it convenient to have a combined FCoE switch with a standard 802 switch. The PropB architecture enables this to be accomplished in multiple useful ways. One straightforward manner to accomplish this is to have the two switches logically connected to each Ethernet port in parallel. The FCoE switch handles the FCoE traffic, and the 802 switches handle the remaining Ethernet traffic. This approach maintains the model the users are accustomed to today; that is, storage switches handle storage traffic (FCoE-SW) and Ethernet bridges handle Ethernet traffic (802).

3 Multipathing and Associating VN_Ports to FCMs

The introduction of Ethernet switches into the network creates an additional complexity that does not exist in standard Fibre Channel. In Fibre Channel, an N_Port is attached to exactly one F_Port. With certain FCoE topologies, it is possible for an N_Port to reach multiple F_Ports. Therefore, a mechanism must be provided in either proposal to associate an N_Port with one of the possibly multiple reachable ports.

The differences in the architectural models result in differences in the way multipathing operates and the method that N_Ports associate themselves with F_Ports. The figures below are used to illustrate these differences:

Note: The following analysis is based on our current understanding of the PropC proposal and makes certain assumptions to finishing the analysis. It is perfectly possible for some of the assumptions to be not valid and our understanding of the proposal is not complete.
Observations / Questions

- PropC requires spanning tree protocol to be enabled on the FCF to eliminate the loops between the internal Ethernet Bridges and the external Ethernet switch. It appears that PropC restricts each Internal Bridge to be in a single VLAN. It will be assumed that each Ethernet Bridge can only participate in a single VLAN. This effectively makes only one external facing port to be in forwarding state on each internal Bridge. All the other ports are in blocked mode. Ensuring multipathing in this configuration will require extensive VLAN and MSTP configuration as described below:

Configuration steps on each Internal Ethernet Bridge (this step does not apply to PropB since PropB does not contain any internal bridges):
   a. Enable multiple spanning tree (MSTP).
   b. Configure one spanning tree per link between each internal bridge and the external switch (so there will be four spanning tree instances). One
would have to configure more if more ISLs are desired between the switches.
c. Configure 4 VLANs. Configure each port on each bridge to be in a separate VLAN. Effectively there are four separate non-overlapping forwarding topologies between the two switches.
d. Now, configure each FCM attached to each internal Bridge to be in separate VLANs. **Note: It's not clear in the PropC proposal that a single FCM behind an Ethernet Bridge in a Type D FCF can participate in multiple VLANs. It will be assumed that it does not.**

**Configuration steps on the External Switch (common to both proposals):**
e. Enable multiple spanning tree (MSTP).
f. Configure one spanning tree per inter switch link. (so there will be four spanning tree instances enabled on both sides since there are a total of four links).
g. Configure 4 VLANs. Configure each ISL to be in separate VLANs.
h. Configure servers facing ports to be in their respective VLANs. Server1 gets VLAN1 and VLAN2. Server2 gets VLAN3 and VLAN4.

- One could argue that link aggregation could be used to solve the above problem. It is not clear that this would work. Note that between a given HBA and FCM, all frames use the same source / destination MAC addresses, and there is no IP content. Therefore, there is no indication for the external switch to allow it to identify separable flows to split between the links. Consequently, even if link aggregation is enabled, it is likely that all of the traffic will flow on a single link.

- With PropB, there are no loops with respect to the FCoE traffic and therefore all of the links remain available. Recall that the PropB model does not include an Ethernet bridge. Consequently, from the point of view of the external bridge, it is the only bridge in the network.

- With PropB, each link between the external switch and the FCoE switch is terminated by an FCoE entity. Therefore, traffic may be shared among all available links.

- In PropB, if the FCoE switch includes a parallel Ethernet switch, the above observations remain true for the FCoE traffic. Of course, normal spanning tree or link aggregation techniques would be required to support the non-FCoE traffic.

- With PropC, it is possible that the external switch will flood the FLOGI to multiple FCMs. This problem is exacerbated if one imagines multiple FCoE switches connected to the external switch. PropC is incomplete in its specification of how this is handled.

- PropB Switches are configured to associate each XN_Port to an XF_Port. This solves the problem of the possible flooding of FLOGI’s. Enabling MMRP/GMRP on the
External switch provides multicast suppression if desired. No server configuration is required.

- PropB does not require any configuration to keep all the provisioned links between the external switch and the FCoE switch to be active. Multipathing works as it would in a standard Fibre Channel fabric. Any lossless, jumbogram capable, but otherwise no frills external Ethernet switch will work just fine.

4 MAC Address Generation

PropB uses conventional MAC addresses, i.e., the globally unique MAC address assigned to the NIC (or the locally administered addresses assigned to the NIC via a virtualization layer) is used for FCoE traffic as well as other non-FCoE traffic.

PropC generates additional locally administered addresses by concatenating an OUI with the corresponding (source or destination) Fibre Channel ID of the encapsulated Fibre Channel frame.

Observations / Questions:

- PropB reduces the total number of MAC addresses that need to be handled by the edge Ethernet switches compared to PropC (since PropC requires two addresses per virtual machine, one for FCoE, and one for everything else, see slide 17 of 07-313v1). This results in reduced L2 forwarding tables and associated learning/aging/flooding overheads in the edge switches, especially when large IO consolidation is deployed through the network.

- PropC requires Independent VLAN Learning deployed to avoid MAC address collisions resulting from same FC-ID assigned in different virtual fabrics. Since this entire set of MAC addresses are indeed processed by the FCF, this stresses the scalability of the internal Ethernet Bridge. This also stresses the HBA implementations in a server consolidation environment, where each bladed server chassis may host 128-256 virtual machines going forward. PropB requires no VLAN deployment.

- PropC appears to specify a one-to-one mapping between VLANs and the Virtual Fabrics. PropB has no such restriction. PropB architecturally decouples VLANs from Virtual Fabrics. This allows for Fibre Channel standard based VF tagging, negotiation and discovery by XN_Ports independent of VLANs. PropC mandates an identity mapping between VID and VFID, thereby restricting the VFs to the VLANs negotiated or configured already. Additionally, this one-to-one mapping requires deployment of Independent VLAN Learning (IVL) in the CEE cloud. Support for IVL is optional in IEEE 802.1. Although IVL are widely available and deployed, they impose scalability limits. Shared VLAN Learning, which is inherently more scalable, does not appear to work with PropC. Again, PropB does not rely on VLANs.
• PropC utilizes locally administered addresses. Other applications, such as certain HPC and virtualized operating systems also generate locally administered addresses. Therefore, there is a potential that conflicts may occur between the independently generated locally administered addresses. PropC attempts to avoid this issue by using an Organizationally Unique Identifier (OUI) as part of its address. However, OUIs have no significance in locally administered addresses and therefore no assurance against address collisions is provided (see clause 9.3 of IEEE Std 802-2001 IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture).

• PropC attempts to make the conversion from Fibre Channel to FCoE stateless. It does not appear that it succeeds in this. When the next hop of the frame is another FCoE switch, then the MAC address of the FCM must be used. This implies state in the conversion process. Edge devices are handled differently using the mapping function. It is not clear that the state saved justifies the increase in FCM complexity.

• PropC appears to increase the complexity on NICs since it requires the XN_Port to remember and listen to multiple locally administered MAC addresses, one per FC-ID assigned. In the case of a virtual NIC, PropC appears to double the number of MAC addresses the NIC must process. PropC appears to have a unique method to rewrite the MAC address if the next hop happens to be the final destination. In this case, PropC utilizes an additional locally administered address that is computed algorithmically. PropB utilizes the same MAC address that, for example, IPv4 or IPv6 frame would use destined to the same device or virtual machine.

5 Data Integrity

Proper operation of the Fibre Channel Protocol requires that frames be delivered through the fabric within \((R_A_{T_{OV}} - E_D_{T_{OV}}) /2\) or that the frame not be delivered. Violating this requirement in certain circumstances can result in undetected data corruption.

In conventional Fibre Channel fabrics, this requirement is met by enforcing a maximum time that a frame can live in a single switch (500ms is typical). However, FCoE fabrics become more complex. It is not hard to imagine a fabric that consists of an FCoE Server, an edge Ethernet Switch, a core Ethernet switch, an FCoE switch providing conversion to Fiber Channel, a Fibre Channel core, and maybe even an additional Fibre Channel edge switch. The number of hops therefore becomes considerably more than what one typically sees in pure Fibre Channel. Additionally, it should be noted that the default frame lifetime specification for Ethernet is one second, and may be configured to up to four seconds (2x to 8x the typical Fibre Channel value).

PropC appears to ignore this issue, which is curious considering that the Type C and Type D models seem to significantly exacerbate this problem. Notice that in these models, a frame must transit two Ethernet switches and a Fibre Channel switch as it passes through each physical switch. In a worse case congested environment, a frame could take just under 2.5 seconds to transit this device. With just two of these devices, it
becomes possible to violate the end-to-end transit requirement and create undetected data corruption.

PropB addresses this issue in the same manner it has been addressed in FC-IFR, FCIP, and iFCP. An optional timestamp is added to each frame allowing an end-to-end (within the FCoE domain) timeout to be enforced. Therefore, the frame lifetime setting of individual Ethernet switches becomes irrelevant.

6 Cut Through and Minimum Frame Length

Ethernet requires a minimum frame length of 64 bytes. The minimum frame length for Fibre Channel is 28 bytes.

PropC requires that padding be added to the Ethernet frame for short Fibre Channel frames to bring the total frame size up to 64 bytes. As a result, a length field is required in the header to indicate the amount of padding present. This has the unfortunate consequence of disabling cut-through operation when transferring a frame from Fibre Channel to Ethernet. This is due to the fact that the entire Fibre Channel frame must be received in order to set the value in the length field.

PropB does not encounter this problem. The headers in PropB are designed to ensure that the minimum frame size is always at least 64 bytes. The overhead of doing this is negligible once one includes the additional information required in the FCoE header that is missing from PropC. Thus cut through operation is not precluded.

7 VE_Port Discovery

PropC provides an automated VE_Port discovery mechanism. PropB provides no such mechanism and could well benefit from this. Additional study is underway.
Appendix A: Response to T11/07-350v0

This appendix provides a detailed response to the comments posted in T11/07-350v0. Each comment is reproduced here. However, reference to T11/07-350v0 is required to obtain the full context of the comment.

Comment: The discussion on Type C and Type D needs to take into consideration the VLANs dimension. In Type C there is an Ethernet Bridge per VLAN. In Type D some VLANs have more than one Ethernet Bridge.

Response: This information has been added to the text.

Comment: This is also true of FCoE: The extreme case of Type D is that there is a bridge per port, basically equivalent to no bridge at all. This restrict the Ethernet link to carry FCoE ONLY. We believe that this case is not interesting since it does not allow I/O consolidation. In all the scenarios presented by IBM, HP, EMC, I/O consolidation is present.

Response: Brocade fully acknowledges and supports the drive for consolidation. The model proposed in PropB in no way restricts the link to carry FCoE traffic. On the contrary, it encourages innovation in this area, as it does not restrict the architecture to only two models of combined FCoE and Ethernet switches. Instead, similar to the model of Ethernet and IP, PropB leaves the combination of functions such as FCoE, IP, Ethernet, FC-IFR, etc., open to the innovation of implementers. Brocade does not believe that it is necessary to specify how these independent functions are implemented in a given package to ensure interoperability. The text has been expanded to clarify this point.

Comment: It is a goal of FCoE to define a single forwarding model that works both for Type C and Type D. FCoE does not privilege one or the other. IMHO I/O consolidation will favorite Type C. Type D is not discouraged.

Response: The text erroneously indicated that type D was discouraged. The intent was to indicate that Type C seemed to be discouraged as it allows direct communication and therefore weakens zoning enforcement. The text has been clarified.

Comment: How this works in Brocade's proposal is not clear at all.

Response: PropB allows freedom in how Ethernet switches are interconnected with FCoE switches. So, by definition, Type C and Type D models are supported. However, the Brocade proposal does not restrict implementations to only these two models. The text has been clarified.
Comment: Without an Ethernet Bridge, how do you propagate non FCoE traffic? You completely miss I/O consolidation!!! The models of Type C and D were not invented for FCoE: they are the models used in the layer 3 IP switches used in Datacenters. FCoE is added as another protocol/application layered on top of Ethernet.

Response: The original wording in this bullet was poorly written, and has been rewritten to make the point correctly. Yes, an Ethernet bridge is required to forward non-FCoE traffic and to achieve IO consolidation. What is not required is to standardize a specific interconnect between the Ethernet bridges and the FCoE switch. This is similar to multilayer Ethernet switches. The individual layers are specified by standards. How the individual layers are interconnected within a particular product is not specified by standards.

Comment: There are no multiple architecture in FCoE. Type C and D are not two separate architectures. They are introduced just to be sure to not take wrong decisions when defining the addressing and forwarding model.

Response: Brocade has no objection to the use of the Class C and D models as illustrations to the t11 committee of how FCoE and Ethernet switches might be interconnected. Brocade objects to the assertion, either by standard or implication, that these are the only two valid or useful ways that these functions might be interconnected.

Comment: FCoE does not change anything in term of Ethernet forwarding. FCoE is layered on top of Ethernet. Ethernet can use ST, MSTP, TRILL or the more revolutionary forwarding scheme that has not yet been invented. FCoE does not care. In this respect FCoE behaves exactly as IPv4 and IPv6. All the rest of section 3 is irrelevant and therefore not commented (with the exception of MMRP, that does not exist).

Response: This is exactly the point. If one restricts oneself to the type C and D models, then one necessarily must utilize the Ethernet forwarding schemes, complete with their limitations. Other models may not necessarily have this restriction and therefore could support routing protocols more familiar to and optimized for storage applications, such as FSPF.

Comment: GMRP and MMRP have ZERO customer deployment and therefore are not relevant. FCoE does not care about GMRP/MMRP, since FCoE is layered on top of Ethernet.

Response: GMRP is widely available, if not widely deployed. The same is likely to become true for MMRP. Both PropB and PropC are layered on top of Ethernet and both use multicast. While not required for either PropB or PropC, a user may decide to use GMRP or MMRP to contain the multicast. It is therefore relevant to either proposal.
Comment: FCoCEE misses the need for MAC addresses, especially in a highly virtualized environment. See 07-313 on this topic. As a result most of the following claims are incorrect.

Response: The need for MAC addresses is clear. What is not clear is the benefit of using PropC specific locally administered addresses in addition to the Ethernet MAC addresses already in use.

Comment: The number of MAC addresses in FCoE is equivalent to the number of addressable vNICs. Keeping less MAC addresses than addressable vNIC (which seems to be what FCoCEE proposes) introduces aliases and reduce the value of FCoE. Again see 07-313 on this topic.

Response: The PropB proposal does need to be clearer on the use of MAC addresses with vNICs. The intent is that in a virtualized environment, PropB would use the same addresses that would be used anyway by the virtual machines, but no new PropB specific addresses would be created. Instead, FCoE traffic is disambiguated from other Ethernet traffic to / from the virtual machine using Ethertype – the same method used to disambiguate all other traffic types to the virtual machine. PropB does not treat the FCoE traffic as a “special case” requiring unique MAC addresses and therefore possibly doubling the number of MAC addresses that the edge switch must deal with.

Comment: Almost all customers deployment uses IVL. SVL is used only in association with particular features like Private VLANs, that are a non goal for FCoE.

Response: Brocade believes that the use of VLANs, regardless of whether they are IVL or SVL, is a non-goal.

Comment: This is true and we think this is a feature. IVL is not an issue.

Response: Brocade does not believe that the consumption of a finite resource (such as VLANs) is advantageous. PropB does not depend on VLANs to implement virtual fabrics. The bullet points out that PropC does depend on the IVL form of VLANs. The bullet appears to be technically correct.

Comment: This is incorrect: Local OUIs can be registered, see:
http://standards.ieee.org/regauth/oui/oui.txt. Any OUI whose second digit is 2,3,6,7,A,B,D,E is a local OUI

Response: The statement is correct. Local OUIs appear to have been registered, but they have no meaning in Ethernet. See clause 9.3 of IEEE Std 802-2001 IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture, which states:

“Protocol identifiers may be assigned universally or locally. The X bit of a protocol identifier is the bit of the first octet adjacent to the M bit. All identifiers
derived from OUIs assigned by the IEEE will have the X bit set to 0 and are universally assigned. Values with the X bit set to 1 are locally assigned and have no relationship to the IEEE-assigned values. They may be used, but there is no assurance of uniqueness.

Furthermore, the statement that any OUI with the second digit of 2, 3, 6, 7, A, B, D, and E is a local OUI does not pass a reasonableness test. If this were true, it would imply that all locally administered addresses are reserved for future reservation, since this set covers the entire locally administered address space.

Comment: FCoE uses the most successful Ethernet rewriting scheme known: the one used in IPv4 and IPv6. IMHO it is up to Brocade to prove that IPv4 and IPv6 are wrong. Good luck!

Response: PropB utilizes the same re-writing scheme, i.e. updating the MAC address at each hop to address the next hop. Both proposals are in agreement with this scheme. Unlike IPv4 and IPv6, PropC appears to have a unique method to rewrite the MAC address if the next hop happens to be the final destination. In this case, PropC utilizes an additional locally administered address that is computed algorithmically. PropB utilizes the same MAC address that an IPv4 or IPv6 frame would use destined to the same device or virtual machine. Brocade does not believe that IPv4 and IPv6 are wrong, and PropB appears to better leverage the concepts of IPv4 and IPv6. The text has been modified to better illustrate PropB’s leverage of IP concepts.

Comment: This is a feature, since future NICs may use this information to demultiplex traffic among vNICs. See 07-313 for additional advantages.

Response: Brocade believes that the least complex method to demultiplex traffic among VNICs is to use the same MAC address for all traffic addressed to a single VNIC (i.e. virtual machine), rather than having two addresses each: one for FCoE and one for everything else. PropC appears to create an additional layer to the demultiplexing function. Instead of demultiplexing all traffic using Ethertype (as is common today), FCoE traffic is handled as a special case and is demultiplexed based on MAC address.

Comment: Why? FCoE is flexible. If the FCM announces its MAC address, then it is learnt, otherwise not. Don't confuse a suggested configuration with a technical limitation.

Comment: The issues of security are not currently addressed by FCoE or FCoCEE. A correct solution will require cryptographically secure messages.

Comment: The same can be done in FCoE, but GMRP/MMRP have ZERO customer deployment.

Comment: With MAC address ACLs.
Response: The security section has been removed from this document. It is not clear that there are any significant differences in the security aspects of either proposal.

Comment: Absolutely not, see 07-313 and 07-303. The issue is correct, the solution proposed by FCoCEE is questionable at best.

Response: Brocade was unable to locate any specific reference in 07-303 to enforcement of frame delivery times, especially with respect to the more complex fabrics one might expect to encounter in FCoE deployments.

The solution proposed by PropB is the same as that used in FCIP, iFCP, and FC-IFR. Given that both IETF and t11 have both found this approach to be acceptable in their standards, it is not clear why it would be considered “questionable at best”.

In 07-313 the claim is made that exceeding the delivery time requirement is unrealistic in today’s switches. It goes on to state VoIP and 10GE as examples. These examples are fundamentally different that what is being proposed for FCoE, that is, a lossless fabric. In a typical “lossy” fabric, it is reasonable to assume that a switch would not hold on to a frame for more than a second, and certainly not four seconds, since huge amounts of buffering would be required. However, once flow control is enabled, the entire argument becomes moot. In fact, the opposite becomes true; switches with small amounts of buffering, and therefore more likely to cause congestion spreading, are more likely to cause excessive frame transit times.

The Type C and Type D models exacerbate this problem. Notice that in these models, a frame must transit two Ethernet switches and a Fibre Channel switch. In a worse case congested environment, a frame could take just under 2.5 seconds to transit this device. With just two of these devices, it becomes possible to violate the end-to-end transit requirement and create undetected data corruption.

In 07-313, it appears that a case is made that this is not an issue using “proof by assertion”. However, it is not clear the 07-313 provides a guarantee.

Comment: FCoCEE misses the importance on the length field. Again see 07-313 and 07-303

Response: Brocade believes that the importance of the length field as used in 07-313 and 07-303 is to allow a device receiving FCoE frames to determine the amount of pad that may have been included in an Ethernet frame to bring it up to the 64-byte minimum Ethernet frame size. Additionally, in 07-313, a hypothetical argument is made that the length field might be useful in allocating buffers on the receiving end node; however, it would seem that the use of the length field for allocating buffers would be of limited use given that only a subset of the frames received (i.e. FCoE frames) would have this length field. The receiving device would need to handle the non-FCoE traffic regardless, and it seems questionable that there would be value in handling the FCoE frames as a special
case. It should also be noted that both Fibre Channel and Ethernet have been able to achieve a high degree of success without a length field.

Brocade has been unable to ascertain any other purpose for the length field.

07-313 illustrates that bytes are wasted in PropB with the SCSI read command. In this case, the high bandwidth demand is on the return path (i.e., from the target to the initiator). Brocade believes that the high bandwidth demand path is the path that demands the greatest optimization. Furthermore, 07-313 overstates the amount of “wasted” bytes as these bytes include critical information such as the timestamp field, which is vital for data integrity.

07-313 also makes the claim that cut-through is not possible when the receiving side is slower than the transmitting side. This, of course, is not correct. While it is true that some of the frame must be received to ensure starvation does not occur on the transmitting side, frame transmission may still commence far before the entire frame is received. This is valuable, for example, going from an 8G FC link to a 10GE link. In addition, it is only prudent to be consider future technologies, such as 40G Ethernet and 16G Fibre Channel, along with evolving link aggregation technologies. Considering these potential advances, it seems rather short-sided to preclude cut-through operation in a new standard.

PropB frames never contain extra padding, and therefore the length field is unnecessary.