July 20, 2000

To: John Lohmeyer, chairperson, T10
From: Bob Snively
Date: July 20, 2000
Subject: Draft of Annex D, FCP-2 revision 5

This document contains a draft of Annex D to be included in FCP-2, revision 5, based on T10/00-137r5. Revision 1 adds the requested corrections discovered during the FCP-2 working group meeting of July 10, 2000.

Note that the complex cases with ambiguous results are not yet included, pending completion of the effort to resolve one particularly intractable corner case.
Annex D  Error detection and recovery action examples
(Informative) [Draft, based on T10/00-137r5]

D.1 Introduction
This annex diagrams various error detection and recovery procedures for SCSI devices conforming to this profile.

Table D.1 - Diagram Drawing Conventions

<table>
<thead>
<tr>
<th>Drawing Convention</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>Acknowledged or Unacknowledged Frame</td>
<td>Acknowledged or Unacknowledged Frame</td>
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<tr>
<td>Acknowledgement Frame</td>
<td>Acknowledgement Frame</td>
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<tr>
<td>Time-out value exceeded, caused transmission of IU or ELS</td>
<td>Time-out value exceeded, caused transmission of IU or ELS</td>
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<tr>
<td>IU or ELS received is processed to transmit IU or ELS</td>
<td>IU or ELS received is processed to transmit IU or ELS</td>
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<tr>
<td>Frame lost or dropped</td>
<td>Frame lost or dropped</td>
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<tr>
<td>Error detection complete. Operation continues with specified Error Recovery if continuously increasing sequence count prerequisites are met.</td>
<td>Error detection complete. Operation continues with specified Error Recovery if continuously increasing sequence count prerequisites are met.</td>
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<tr>
<td>Error detection complete. Operation continues with specified Error Recovery if continuously increasing sequence count prerequisites are not met.</td>
<td>Error detection complete. Operation continues with specified Error Recovery if continuously increasing sequence count prerequisites are not met.</td>
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</table>
No Error Recovery

None: The ACC for the REC indicates the Exchange is open and the Target holds Sequence Initiative. No error recovery is required.
The LS_RJT (Logical Error, Invalid OX_ID/RX_ID combination) for the REC indicates the Exchange is unknown. The FCP_CMND is retransmitted in a new Exchange using the same CRN and in the same class of service.
Figure D.3 - FCP_CMND Lost, Acknowledged Classes

The BA_ACC indicates that the FCP_CMND was never received. (BA_ACC payload: SEQ_ID Validity = invalid, Low SEQ_CNT = 0, High SEQ_CNT = SEQ_CNT of ABTS frame). Both the initiator and target establish Recovery Qualifiers. The value of R_A_TOV for in-order delivery is zero. The use of REC to determine status for error recovery is optional.

The FCP_CMND is retransmitted in a new Exchange using the same CRN and in the same class of service.
No error recovery required. The BA_ACC Payload indicates that FCP_CMND was received. The BA_ACC payload is SEQ_ID Valid, SEQ_ID value of FCP_CMND, low SEQ_CNT = high SEQ_CNT = SEQ_CNT of FCP_CMND. Note that the issuance of RRQ is not necessary in this case, since the target will not have established a Recovery Qualifier. However, the initiator cannot reclaim the resources associated with its Recovery Qualifier until R_A_TOV time-out expires. The value for R_A_TOV is 0 for in-order delivery. The use of REC to determine status for error recovery is optional.
The ACC for the REC indicates the Initiator holds Sequence Initiative and the Exchange is open. The Initiator sends an SRR requesting the FCP_XFER_RDY be resent. The Target resends the FCP_XFER_RDY using the same Relative Offset. A new SEQ_ID must be used for retransmission of the FCP_XFER_RDY. For in-order delivery, the value of REC_TOV* is 0.

**Error Detection**

- REC_TOV
- Wait REC_TOV*. If FCP_XFER_RDY is returned, continue with the Exchange. (ACC to REC arrived before FCP_XFER_RDY, out of order). Otherwise continue recovery.

**Error Recovery**

The ACC for the REC indicates the Initiator holds Sequence Initiative and the Exchange is open. The Initiator sends an SRR requesting the FCP_XFER_RDY be resent. The Target resends the FCP_XFER_RDY using the same Relative Offset. A new SEQ_ID must be used for retransmission of the FCP_XFER_RDY. For in-order delivery, the value of REC_TOV* is 0.
For acknowledged classes, the BA_ACC indicates that the FCP_XFER_RDY was never received by the initiator. The BA_ACC payload is SEQ_ID invalid, low SEQ_CNT = 0, high SEQ_CNT = SEQ_CNT in ABTS frame = 1. Both target and initiator must establish Recovery Qualifiers. The value for R_A_TOV* for in-order delivery is 0. A new SEQ_ID must be used in the retransmission of FCP_XFER_RDY. The use of REC to determine status for error recovery is optional.
The BA_ACC indicates that the FCP_XFER_RDY was received by the initiator. The BA_ACC payload of SEQ_ID valid, SEQ_ID = SEQ_ID of the FCP_XFER_RDY frame, low SEQ_CNT = high SEQ_CNT = SEQ_CNT of the ABTS frame. No error recovery is required. There is no need for the target to issue the RRQ since no Recovery Qualifier was established by the initiator in this case. It must still let R_A_TOV* expire before reclaiming the resources associated with its Recovery Qualifier. The value of R_A_TOV* for in-order delivery is 0, The use of REC to determine status for error recovery is optional.
The ACC for the REC indicates the Initiator holds Sequence Initiative and the Exchange is complete. The Initiator sends an SRR requesting the FCP_RSP be resent. The Target retransmits the FCP_RSP. For in-order delivery, the value of REC_TOV* is 0. For sequence level recovery, the target must keep the context of this Exchange as defined in 12.XXX. For exchange level recovery, the context of the Exchange can be purged by the target after FCP_RSP is transmitted.
BA_ACC to ABTS indicates that the FCP_RSP was never received by the initiator. The payload is SEQ_ID invalid, low SEQ_CNT = 0, high SEQ_CNT = SEQ_CNT in ABTS frame = 1. Both initiator and target must establish Recovery Qualifiers. The value of $R_A\_TOV^*$ for in-order delivery is 0. A new SEQ_ID must be used in the retransmission of FCP_RSP. The use of REC to determine status for error recovery is optional.
BA_ACC to ABTS indicates that the FCP_RSP was never received by the initiator. The payload is SEQ_ID valid, SEQ_ID = SEQ_ID of FCP_DATA Sequence, low SEQ_CNT = x, high SEQ_CNT = SEQ_CNT in ABTS frame. Both initiator and target must establish Recovery Qualifiers. The value of R_A_TOV* for in-order delivery is 0. A new SEQ_ID must be used in the retransmission of FCP_RSP.

The use of REC to determine status for error recovery is optional.
No error recovery required.

The BA_RJT for the ABTS indicates with reason code of Logical Error and the reason explanation code of Invalid OX_ID-RX_ID Combination that the Exchange is unknown and therefore complete. No error recovery is required. The target must establish a Recovery Qualifier. The associated resources cannot be reused for a period of R_A_TOV. For in-order delivery, the value of R_A_TOV is 0. The target does not need to issue RRQ as no Recovery Qualifier was established by the initiator.
No recovery performed.
The BA_RJT for the ABTS indicates that the Exchange is unknown and therefore complete and no error recovery is required. The target must establish a Recovery Qualifier. The associated resources cannot be reused for a period of R_A_TOV.
No action is taken on ABTS until the ACK to the outstanding Sequence has been received, allowing the analysis to take into consideration the RX_ID, to eliminate ambiguity.
For in-order delivery, the value of R_A_TOV* is 0.
The target need not issue RRQ, as no Recovery Qualifier was established by the initiator.
The ACC for the REC indicates the Target does not hold Sequence Initiative and the Exchange is open. The Initiator sends an SRR requesting a FCP_XFER_RDY be resent using the specified Relative Offset. The Target retransmits the FCP_XFER_RDY using the specified Relative Offset. New SEQ_IDs are used for FCP_XFER_RDY and FCP_DATA retransmission.
Using the information contained in the REC, the recovery may be performed as in figure D.13. The BA_ACC may also be used. The payload is SEQ_ID = valid, SEQ_ID = SEQ_ID of FCP_CMND, low SEQ_CNT of 0, high SEQ_CNT of 2.

New SEQ_IDs shall be used for retransmitting FCP_XFER_RDY and FCP_DATA. ACKs for REC/ACC and RRQ/ACC are not shown. The value of R_A_TOV* for in-order delivery is 0.
Error Detection

The ACC for the REC indicates the Target does not hold Sequence Initiative and the Exchange is open. The Initiator sends an SRR requesting a FCP_XFER_RDY be resent using the specified Relative Offset. The Target retransmits the FCP_XFER_RDY using the specified Relative Offset. New SEQ_IDs are used for FCP_XFER_RDY and FCP_DATA retransmission.

If the lost frame arrives at the target prior to the expiration of REC_TOV, the exchange proceeds and no recovery is required.

Error Recovery

The ACC for the REC indicates the Target does not hold Sequence Initiative and the Exchange is open. The Initiator sends an SRR requesting a FCP_XFER_RDY be resent using the specified Relative Offset. The Target retransmits the FCP_XFER_RDY using the specified Relative Offset. New SEQ_IDs are used for FCP_XFER_RDY and FCP_DATA retransmission.

If the lost frame arrives at the target prior to the expiration of REC_TOV, the exchange proceeds and no recovery is required.
Using the information contained in the REC, the recovery may be performed as in figure D.15. The BA_ACC may also be used. The payload is SEQ_ID = valid, SEQ_ID = SEQ_ID of FCP_CMND, low SEQ_CNT of 0, high SEQ_CNT of 2. New SEQ_IDs shall be used for retransmitting FCP_XFER_RDY and FCP_DATA. ACKs for REC/ACC and RRQ/ACC are not shown. The value of R_A_TOV* for in-order delivery is 0.
Error Detection

If FCP_DATA (seq=1, cnt=1) is received during REC_TOV, then no error occurred and the exchange is completed.

Error Recovery

The ACC for the REC indicates the Target does not hold Sequence Initiative and the Exchange is open. The Initiator sends an SRR requesting a FCP_DATA be resent using the specified Relative Offset. FCP_DATA retransmission uses a new SEQ_ID. For in-order delivery, the value of REC_TOV* is 0.
Using the information contained in the REC, the recovery may be performed as in figure D.17. The BA_ACC may also be used because it indicates that the FCP_DATA sequence was not completely received. The payload is SEQ_ID = invalid, low SEQ_CNT of 0, high SEQ_CNT of ABTS frame. New SEQ IDs shall be used for retransmitting FCP_DATA. ACKs for REC/ACC and RRQ/ACC are not shown. The value of R_A_TOV* for in-order delivery is 0.
The ACC for the REC indicates the Target does not hold Sequence Initiative and the Exchange is open. The Initiator sends an SRR requesting a FCP_DATA be resent using the specified Relative Offset. FCP_DATA retransmission uses a new SEQ_ID. For in-order delivery, the value of REC_TOV* is 0.

**Error Detection**

**Error Recovery**

If FCP_DATA (seq=1, cnt=0) is received during REC_TOV, then no error occurred and the exchange is completed.
Error Detection

Using the information contained in the REC, the recovery may be performed as in figure D.17. The BA_ACC may also be used because it indicates that the FCP_DATA sequence was not completely received. The payload is SEQ_ID = invalid, low SEQ_CNT of 0, high SEQ_CNT of ABTS frame.

New SEQ_IDs shall be used for retransmitting FCP_DATA. ACKs for REC/ACC and RRQ/ACC are not shown. The value of R_A_TOV* for in-order delivery is 0.

Error Recovery

If sequence error is not detected, ACK timeout will be detected with same result.
Error Detection

Acknowledged Classes

No Error Recovery

None:
The Initiator has received the FCP_DATA frame or sequence. No error recovery is required.

The BA_ACC indicates the FCP_DATA sequence was received (Payload is SEQ_ID valid, SEQ_ID value = SEQ_ID value of FCP_DATA sequence, low SEQ_CNT = high SEQ_CNT = SEQ_CNT of ABTS frame).

The target must establish its Recovery Qualifier. The resources associated with the Recovery Qualifier can be reclaimed after R_A_TOV. For in-order delivery, the value of R_A_TOV* is 0.

The issuance of RRQ is optional as no Recovery Qualifier was established by the initiator in this case. FCP_RSP can be received anytime after the transmission of FCP_CMND due to out of order delivery.
Error Recovery

None:
The Target has received the FCP_DATA sequence. No error recovery is required.
The BA_ACC indicates the data sequence was received. The payload is set to SEQ_ID valid, SEQ_ID value = SEQ_ID value of the FCP_DATA sequence, low SEQ_CNT = high SEQ_CNT = SEQ_CNT of ABTS frame. The target and initiator continue the Exchange.
The initiator must establish its Recovery Qualifier. The resources associated with the Recovery Qualifier can be reclaimed after R_A_TOV. For in-order delivery, the value of R_A_TOV* = 0. The issuance of the RRQ is optional, as no Recovery Qualifier was established by the target. FCP_RSP can be received at any time after the last FCP_DATA frame has been transmitted.
None.
The LS_RJT for the REC indicates the Exchange is unknown. That implicitly indicates that the initiator received FCP_RSP and sent FCP_CONF.
The context for the Exchange in the Target must be preserved for another R_A_TOV to prevent possible aliasing. If FCP_CONF is received after REC is transmitted, it is accepted and discarded and the context for the Exchange can be purged. For in-order delivery, the value of R_A_TOV* = 0.
The BA_ACC indicates that the FCP_CONF was not received. The BA_ACC payload is SEQ_ID valid, SEQ_ID value = SEQ_ID of FCP_CMND, Low SEQ_CNT = 0, High SEQ_CNT = 1). The value of R_A_TOV* for in-order delivery is zero. FCP_CONF must be retransmitted with a different SEQ_ID.

Error Recovery

The BA_ACC indicates that the FCP_CONF was not received. The BA_ACC payload is SEQ_ID valid, SEQ_ID value = SEQ_ID of FCP_CMND, Low SEQ_CNT = 0, High SEQ_CNT = 1). The value of R_A_TOV* for in-order delivery is zero. FCP_CONF must be retransmitted with a different SEQ_ID.
None:
BA_RJT is the response to the ABTS, since no context exists for this Exchange and the ABTS was not issued on the first sequence of a new Exchange. The initiator must establish a Recovery Qualifier on receipt of the BA_RJT. The resources associated with the Recovery Qualifier can be reclaimed when R_A_TOV expires.
Issuance of the RRQ is optional, as no Recovery Qualifier was established by the target. For in-order delivery, the value of R_A_TOV\(^*\) = 0.
For the case of the REC never having been received, the BA_ACC payload will be SEQ_ID invalid, low SEQ_CNT = 0, high SEQ_CNT = SEQ_CNT of ABTS = 1.

For the case of the ACC response to REC never having been received, the target would view the ABTS as having been issued on a new Exchange. The BA_ACC payload will be SEQ_ID invalid, low SEQ_CNT = high SEQ_CNT = SEQ_CNT of ABTS.

In both cases, a Recovery Qualifier will be established. The second REC is issued in a new Exchange. For in-order delivery, the value of R_A_TOV* is 0.
Error Recovery

The BA_ACC payload indicates that the REC was never received by the target. The payload is SEQ_ID invalid, low SEQ_CNT = 0, high SEQ_CNT = SEQ_CNT in ABTS frame. Recovery Qualifiers are established on each side.

For in-order delivery, the value of R_A_TOV* is 0.

The second REC is issued using a new Exchange.
The BA_ACC payload indicates that the ACC was never received by the initiator. The payload is SEQ_ID invalid, low SEQ_CNT = 0, high SEQ_CNT = SEQ_CNT in ABTS frame. After responding to the ABTS, the initiator reissues the REC in a new Exchange. Recovery Qualifiers are established on each side. For in-order delivery, the value of R_A_TOV* is 0.
The failure of two RECs issued against the same Exchange causes all associated Exchanges to be aborted. The ABTS for the original Exchange uses the previous SEQ_ID and a SEQ_CNT one greater than the count used in the previous sequence and Bit 0 = 0 set in the Parameter field. The payload for the BA_ACC is SEQ_ID valid, SEQ_ID = SEQ_ID of last deliverable sequence received, low SEQ_CNT = 0 and high SEQ_CNT = FFFFh. Recovery qualifiers are established on both sides for each Exchange. For in-order delivery, the value of $R_A_TOV^*$ is 0.
The payload for the BA_ACC associated with the ABTS of the SRR is SEQ_ID invalid, low SEQ_CNT = 0, high SEQ_CNT = SEQ_CNT of the ABTS frame.

The ABTS for the original Exchange uses the previous SEQ_ID and a SEQ_CNT one greater than the count used in the previous Sequence and Bit 0 = 0 in the Parameter field. The payload for the BA_ACC associated with the ABTS for the original Exchange is SEQ_ID valid, the SEQ_ID = SEQ_ID of the last deliverable Sequence of the original Exchange received, low SEQ_CNT = 0, and high SEQ_CNT = FFFFh. Recovery Qualifiers are established on both sides for each Exchange. For in-order delivery, the value of R_A_TOV* is 0.
If the SRR Exchange is unknown to the Recipient, the Exchange was completed and the context purged. The payload for the BA_ACC is SEQ_ID invalid, low SEQ_CNT = 0, high SEQ_CNT = FFFFh. Recovery Qualifiers are established on both sides.

If the SRR Exchange is still known to the Recipient, the payload for the BA_ACC is SEQ_ID valid, SEQ_ID = SEQ_ID of the SRR, low SEQ_CNT = high SEQ_CNT = SEQ_CNT of the ABTS frame. Since no Recovery Qualifier is established, RRQ need not be issued. The Recovery Qualifier is established on the initiator side and must be timed out for R_A_TOV.

For in-order delivery, the value of R_A_TOV* is 0.

In either case, the original Exchange need not be aborted.

The RRQ references the exchange of the SRR.
Since the ABTS on the SRR is on a new Exchange, Recovery Qualifiers must be established. The BA_ACC payload indicates SEQ_ID invalid, low SEQ_CNT = 0, and high SEQ_CNT = SEQ_CNT of the ABTS.

An error on an SRR is a second error and the original Exchange is also aborted. SRR is not retried.

For in-order delivery, the value of R_A_TOV* is 0.
The BA_ACC of the ABTS associated with the SRR indicates that the ACC for the SRR was not received and will be discarded if it is later received. The BA_ACC payload indicates SEQ_ID invalid, low SEQ_CNT = 0, and high SEQ_CNT = SEQ_CNT of the ABTS. The retry of the ACC for SRR is issued with a new SEQ_ID. Recovery Qualifiers are established on each side. For in-order delivery, the value of R_A_TOV* is 0.