Ladder Diagrams for Error Recovery For FCP -2 Rev 04
Out-Of-Order Delivery- Annex D

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June 8, 2000
T10/00-137r5

Reference: T11/00-133r1, r2, r3 and r4
Summary of Changes

• Made all changes generated from the FCP-2 Letter Ballot Review meeting on June 7, 2000.
D.1 Class 3 Error Detection

(Continue with error recovery)
D.1 Class 2 Error Detection

REC can be optionally used at any time to ascertain status of an Exchange. It can also be used in conjunction with ABTS(Sequence) to obtain additional information useful in the Error Recovery process.
D.2 Class 3 FCP_CMD Lost

(Continue with error recovery)
Error Recovery

The BA_ACC indicates that the FCP_CMD 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 0.. The use of REC to determine status for error recovery is optional.
D.2.1 Class 2 Lost ACK on FCP_CMND

No error recovery. The BA_ACC Payload indicates that FCP_CMD 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.
D.3 Class 3 FCP_XFER_RDY Lost

WAIT REC_TOV. IF FCP_XFER_RDY IS RETURNED,
CONTINUE WITH EXCHANGE--REC ARRIVED
BEFORE FCP_XFER_RDY SENT

ERROR RECOVERY

Error Recovery Addition
A new SEQ_ID must be used for the retransmission of the FCP_XFER_RDY.
For in-order delivery, the value of REC_TOV* is 0.
D.3 Class 2 FCP_XFER_RDY Lost

For Class 2 the BA_ACC indicates that the FCP_XFER_RDY was never received by the Initiator. (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.
D.4 Class 2 FCP_XFER_RDY Rcvd, ACK Lost

The BA_ACC indicates that the FCP_XFER_RDY was received by the Initiator, 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. Note: 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.
D.5 Class 3 FCP_RESP Lost, No FCP_CONF Req.

WAIT REC_TOV. IF FCP_RESP RECEIVED, COMPLETE THE EXCHANGE. OTHERWISE DO ERROR RECOVERY

For Sequence level recovery, the Target must keep the context of this Exchange until the OX_ID value is reused in a new command, implicitly validating the receipt of FCP_RESP, or for at least RR_TOV, in order to preserve the FCP_RESP information. This long timeout can be avoided by using FCP_CONF. The FCP_RESP retransmission must use a new SEQ_ID.

For Exchange level recovery, the context of the Exchange can be purged by the Target after FCP_RESP is transmitted. Incorporate the above in the text

For in-order delivery, the value of REC_TOV* is 0.
D.5 Class 2 FCP_RESP Lost, No FCP_CONF Req

Error Recovery
BA_ACC indicates that FCP_RESP was never received by the Initiator (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_RESP.

The use of REC to determine status for error recovery is optional.
BA_ACC indicates that FCP_RESP was never received by the Initiator (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_RESP. The use of REC to determine status for error recovery is optional.
D.6 Class 2 FCP_RESP Rcvvd, ACK Lost

None:
The BA_RJT for the ABTS indicates 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. (See D.5 where the same OX_ID is used before the expiration of R_A_TOV). For in-order delivery, the value of R_A_TOV is 0.
Note: The Target need not issue RRQ as no Recovery Qualifier was established by the initiator.
None:
The BA_RJT for the ABTS indicates 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. Note that 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. (See D. 5?? For another case.) For in-order delivery, the value of R_A_TOV* = 0
Note: The Target need not issue RRQ as no Recovery Qualifier was established by the initiator.
D.7 Class 3  Lost Write Data, Last Frame of Seq.

Continue with error recovery. New SEQ_IDs must be used for FCP_XFER_RDY and FCP_DATA retransmission.
BA_ACC indicates by its payload, that FCP_DATA Sequence was not completely received (Payload: SEQ_ID valid, SEQ_ID value = SEQ_ID of FCP_CMND, low SEQ_CNT of 0 not equal to high SEQ_CNT of 2). New SEQ_IDs shall be used for the retransmission of FCP_XFER_RDY and FCP_DATA. The ACKs for REC/ACC are not shown. The value of R_A_TOV* for in-order delivery is 0.
D.8 Cl 3, Lost Write Data, Not Last Fr. of Seq.

Continue error recovery. New SEQ_IDs must be used for FCP_XFER_RDY and FCP_DATA retransmission.

(If the lost data frame arrives at the Target prior to the expiration of REC_TOV, then the Exchange proceeds and no recovery is required.)
D.8 Class 2  Lost Write Data, Not Last Frame of Seq.

**Error Recovery Addition**

BA_ACC indicates by its payload, that the FCP_DATA Sequence was not completely received (Payload: SEQ_ID valid, SEQ_ID value = SEQ_ID of FCP_CMND, low SEQ_CNT of 0 not equal to high SEQ_CNT of 2). New SEQ_IDs shall be used for retransmission of FCP_XFER_RDY and FCP_DATA. Note that if all data frames arrive at the Target prior to the expiration of E_D_TOV (out-of-order), then there is no error and no recovery is necessary. ACKs for REC/ACC are not shown. The value of R_A_TOV* for in-order delivery is 0.
D.9 Class 3 Lost Read Data, Last Frame of Seq.

If FCP_DATA (seq=1, cnt=1) is received during REC_TOV, then complete the Exchange.

Error Recovery

Continue error recovery. FCP_DATA retransmission must use a new SEQ_ID.
For in-order delivery, the value of REC_TOV* is 0.
D.9 Class 2 Lost Read Data, Last Frame of Seq

Error Recovery Addition

BA_ACC indicates by its payload, that the FCP_DATA Sequence was not completely received (Payload: SEQ_ID invalid, low SEQ_CNT of 0 not equal to high SEQ_CNT of the ABTS frame of 2). A new Sequence ID shall be used for retransmission of FCP_DATA. The value of R_A_TOV* for in-order delivery is 0. The ACKs for REC/ACC are not shown.
D.10 Class 3 Lost Read Data, Not Last Frame of Seq

If FCP_DATA (seq=1, cnt=0, RO=0) is received within REC_TOV*, then proceed with or finish the Exchange.

Error Recovery
Continue error recovery. A new SEQ_ID must be used for the retransmission of FCP_DATA. For in-order delivery the value of REC_TOV* is 0
D.10 Class 2 Lost Read Data, Not Last Frame of Seq

BA_ACC indicates by its payload, that the FCP_DATA Sequence was not completely received (Payload: SEQ_ID invalid, low SEQ_CNT of 0 not equal to high SEQ_CNT of the ABTS frame of 2). A new Sequence ID shall be used for retransmission of FCP_DATA. Note that if all data frames arrive at the initiator before E_D_TOV expires, then no recovery is required; a frame or frames arrived out-of-order. For in-order delivery the value of R_A_TOV* is 0. The ACKs for REC/ACC are not shown.
D.11 Class 2 ACK Lost on Read

Error Recovery

None:
The initiator has received the FCP_DATA Sequence. No error recovery is required.

Note: 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).

Note: 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_RESP can be received anytime after the transmission of FCP_CMD due to out-of-order delivery.
**D.12 Class 2 ACK Lost on Write**

<table>
<thead>
<tr>
<th>FCP_CMND</th>
<th>ACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCP_XFER_RDY (R0=0)</td>
<td></td>
</tr>
</tbody>
</table>

| ACK |
| FCP_DATA (seq=1, cnt=0, RO=0) |

| ACK |
| FCP_DATA (seq=1, cnt=1) |

<table>
<thead>
<tr>
<th>E_D_TOV</th>
<th>ABTS</th>
<th>X</th>
<th>ACK</th>
</tr>
</thead>
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<td></td>
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<table>
<thead>
<tr>
<th>R_A_TOV*</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACK</td>
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</table>

| ACK |
| FCP_RSP |

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**Error Recovery**

None: The Target received the FCP_DATA sequence. No error recovery is required.

Note: The BA_ACC indicates the data sequence was received (Payload is 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_RESP can be received at any time after the last FCP_DATA frame has been transmitted.
None.
LS-RJT implicitly indicates that the Initiator received FCP_RESP and sent FCP_CONF, since no context exists for the Exchange.
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.
D.?? Class 2 FCP_CONF Lost

Error Recovery
BA_ACC payload indicates that FCP_CONF was not received (low SEQ_CNT=0, not equal to high SEQ_CNT =1, SEQ_ID valid, SEQ_ID value =SEQ_ID of FCP_CMND). FCP_CONF* must be sent with a different SEQ_ID. For in-order delivery the value of R_A_TOV* is 0.
D.??? Class 2 ACK Lost on FCP_CONF

Error Recovery

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. Note that the issuance of RRQ is optional as no Recovery Qualifier was established by the Target. For in-order delivery, the value of R_A_TOV* = 0.
Error recovery shall not be attempted if multiple errors, or the appearance of multiple errors, have occurred in an Exchange, such as both the ACK to command and the response to the command being lost. A multiple error arises when a Recovery Qualifier has been established and then either an ABTS is received or the recovery action indicates the need to send an ABTS. The Exchange shall be aborted by issuing ABTS(Abort Sequence) if called for in the recovery process or by setting the Last_Sequence bit to one in BA_ACC with payload of SEQ_ID Validity = invalid, Low SEQ_CNT=hex ‘0000’, High SEQ_CNT=hex ‘FFFF’, or both. For in-order delivery, the value of R_A_TOV* = 0
D.5 Multiple Error Condition, Exchange Ambiguities, Abort the Exchange

Error Recovery

Reuse of Exchange IDs can produce ambiguities. In the event of multiple errors, the current Exchange shall be aborted.

1. The Initiator shall not act on the ABTS until either the ACK to FCP_CMND is received or E_D_TOV expires.
D.13 Cl 3, REC Lost

Since the REC was never received by the Target, the BA_ACC payload is SEQ_ID invalid, low SEQ_CNT =0, high SEQ_CNT= SEQ_CNT of ABTS=1. Recovery qualifiers are established on both sides. The second REC must be issued in a new Exchange. For in-order delivery the value of R_A_TOV* is 0.
Change E_D_TOV in the text to R_A_TOV in 12.6.2
Since the Target has already responded with ACC then no context exists for the Exchange. The Target would view the ABTS as being issued on a new Exchange, establish a Recovery Qualifier and respond with BA_ACC (Payload is SEQ_ID invalid, low SEQ_CNT=high SEQ_CNT= SEQ_CNT of ABTS). Since REC does not change any state, it can be reissued unconditionally. The second REC must be issued in a new Exchange. For in-order delivery the value of R_A_TOV is 0.

Change E_D_TOV in the text to R_A_TOV in 12.6.2
D.13? Cl 3, Two RECs Lost, Abort the original Exchange

The failure of two RECs issued against the same Exchange, causes all associated Exchanges to be 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 Validity =valid, SEQ_ID = SEQ_ID of last deliverable Sequence received, low SEQ_CNT=hex ‘0000” and high SEQ_CNT=hex ‘FFFF”.

Recovery Qualifiers are established on both sides for each Exchange. For in-order delivery, the value of R_A_TOV* = 0.

(In the text 12.6.2. add sentence specifying that if two RECs fail, the original Exchange is aborted, regardless of Class.)

(Out of context: Need to put somewhere in the text, that any ABTS or RRQ failure causes the Exchange to be aborted.)
The BA_ACC payload indicates that the REC was never received by the Target (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.
Note: The Target determines that the ACC was never received by the Initiator; BA_ACC payload is SEQ_ID invalid, Low SEQ_CNT=0, High SEQ_CONT= SEQ_CNT of ABTS. After responding to the ABTS, the Initiator reissues the REC in a new Exchange. For in-order delivery, the value of R_A_TOV* is 0.
D.14a Class 3, SRR Lost, Abort the Original Exchange

Note: The SRR BA_ACC Payload is: SEQ_ID Validity = valid, 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 set in the Parameter Field. The Payload for the BA_ACC is: SEQ_ID Validity = valid, SEQ_ID=SEQ_ID of last deliverable Sequence received, low SEQ_CNT=hex ‘0000” and high SEQ_CNT=hex ‘FFFF”. Recovery Qualifiers are established on both sides for each Exchange. For in-order delivery, the value of R_A_TOV* is 0.

(In the text in 12.6.3, add a note that for Class 3 that an SRR failure causes the original Exchange to be aborted. In Class 2, 2 failures of SRR cause the original Exchange to be aborted. Change E_D_TOV in the text to 2*R_A_TOV to agree with the text in 12.6.3)
Note: If the Exchange is unknown to the Recipient (Exchange completed and context purged) the Payload for the BA_ACC is: low SEQ_CNT = hex ’0000’, high SEQ_CNT = hex ‘FFFF’, SEQ_ID Validity = invalid. Recovery Qualifiers are established on both sides. Otherwise if the Recipient has knowledge of the SRR (last deliverable Sequence), the Payload is SEQ_ID Validity = valid, and 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 on the Target side, 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.

(Note out of context: If the response to SRR is LS_RJT, then the original Exchange shall be aborted or treated as if it had been aborted by the Exchange Initiator, if it is still active--add to 8.3text, hard copy page 33.)
Since this is an ABTS on a new Exchange, Recovery Qualifiers must be established. BA-ACC indicates Invalid SEQ_ID, low SEQ_CNT= 0 and high SEQ_CNT = SEQ_CNT of the ABTS. An error on SRR is a second error and the original Exchange is aborted. SRR is not retried. For in-order delivery, the value of R_A_TOV* is 0.
D.14d  Class 2, SRR Response Lost

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