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

Carl Zeitler
Compaq Computer Corporation
March 28, 2000
T10/00-137r2

Reference: T11/00-133v1
Summary of Major Changes

- Removed the use of REC for Class 2 except for data transfer error cases.
  - REC gives no new info over and above ABTS
  - Simplifies Class 2 recovery
  - Class 2 recovery more consistent within itself
- Added text to show payload of BA_ACC
- Removed the optional issue of RRQ from the Flow Diagrams
- Added RR_TOV timeout to FCP_RESP (See D.5)
- Added D.5 and D.5a to cover action item--double error situation and possible OX_ID confusion.
- D.13 Class 3, split out REC lost and REC Response lost cases.
- Removed last chart, Use of REC in Class 2. REC is useful in cases where FCP_DATA frames are lost and the whole data transfer sequence is not necessarily repeated.
D.1 Class 3 Error Detection

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

- **FCP_CMND**
- **REC_TOV**
- **REC**
- **ACK**
- **ACK**
- **ACK**
- **ACC**

(Continue with error recovery)
D.2 Class 3 FCP_CMD Lost

(Continue with error recovery)
D.2 Class 2 FCP_CMD Lost

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. FCP_CMD* is resent in a new Exchange with a new SEQ_ID.
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.
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 Addition

A new SEQ_ID must be used for the retransmission of the FCP_XFER_RDY.
The BA_ACC indicates that the FCP_XFER_RDY was never received by the Target. (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. A new SEQ_ID must be used in the retransmission of FCP_XFER_RDY and the SEQ_CNT value used must be one greater than the value used in the ABTS frame. REC/ACC are not shown.
D.4 Class 2 FCP_XFER_RDY Rcvd, ACK Lost

None:
The BA_ACC indicates that the FCP_XFER_RDY was received by the Target, 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.
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

Note that the Target must keep the context of this Exchange intact (ESAT in ESB indicates Open) 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. (Note that if recovery is done on an Exchange basis, then the Exchange can be completed in the Target and no RR_TOV is required. If REC were then issue, the response would be LS_RJT.)

Change to Error Recovery text: The ACC for the REC indicates the Initiator holds Sequence Initiative and the Exchange is open for Sequence level recovery and Complete for Exchange level recovery. (It is counter intuitive to restart and Exchange that has been competed.)
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. A new SEQ_ID must be used in the retransmission of FCP_RESP and the SEQ_CNT value used must be one greater than the value used in the ABTS frame.
D.5a Class 2 FCP_RESP Lost after a Write Cmnd, No FCP_CONF Req.

Error Recovery

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=0, high SEQ_CNT=SEQ_CNT in ABTS frame=1.) Both Initiator and Target must establish Recovery Qualifiers. A new SEQ_ID must be used in the retransmission of FCP_RESP and the SEQ_CNT value used must be one greater than the value used in the ABTS frame.
D.6 Class 2 FCP_RESP Rcvd, 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.
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.)
D.7 Class 2 Lost Write Data, Last Frame of Seq.

Error Recovery Addition

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. For Class 2 the starting SEQ_CNT value used with FCP_DATA must one greater than the value used in ABTS. The ACKs for REC/ACC are not shown.
D.8 Cl 3, Lost Write Data, Not Last Fr. of Seq.

FCP_CMND

FCP_XFER_RDY ( R0=0)

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

FCP_DATA (seq=1, cnt=1)

REC_TOV

(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.)

REC

ACC

(Continue error recovery. New SEQ_IDs must be used for FCP_XFER_RDY and FCP_DATA retransmission.)
D.8 Class 2 Lost Write Data, Not Last Frame of Seq.

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. For Class 2 the Sequence count value used with the retransmission of FCP_DATA must be one greater than the value used in ABTS. 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.
D.9 Class 3 Lost Read Data, Last Frame of Seq.

FCP_CMND

FCP_DATA seq=1, cnt=0, RO=0

X

FCP_DATA (seq=1, cnt=1)

FCP_RESP

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

REC

ACC

(Continue error recovery. FCP_DATA retransmission must use a new SEQ_ID.)
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.
For Class 2, the Sequence count value used with the retransmission of FCP_DATA shall be one greater than the value used in ABTS. 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.)

(Continue error recovery. A new SEQ_ID must be used for the retransmission of FCP_DATA.)
D.10 Class 2 Lost Read 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 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. For Class 2, the SEQ_CNT used with the retransmission of FCP_DATA shall be one greater than the value used in ABTS. 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. The ACKs for REC/ACC are not shown.
D.11 Class 2 ACK Lost on Read

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. 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.12a Class 2 ACK Lost on Write

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. 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.
D.1 Class 3 FCP_CONF Lost

Error Recovery

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.
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)
* Second FCP_CONF must be sent with a different SEQ_ID and the SEQ_CNT value must be one greater than the value used in the ABTS frame.
D.??? Class 2 ACK Lost on FCP_CONF

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.
D.5? Class 2 ACK to FCP_CMND and FCP_RESP Lost, no FCP_CONF Req.

Error Recovery

TWO Recovery Qualifiers are established on the Initiator side. One based on the ABTS sent by the Initiator to discard the ACK/Link Response frame to the FCP_CMND and the other, as a Sequence recipient, to discard the FCP_RESP, based on the ABTS issued by the Target. Only one Recovery Qualifier is established by the Target based on the ABTS that it sends to the Initiator. Since the FCP_CMND was received, the Sequence is complete from the Target perspective and no Recovery Qualifier is needed. Thus the issuance of RRQ by the Initiator is optional and the response would be LS_RJT.

1. The payload is SEQ_ID invalid, low SEQ_CNT = 0, high SEQ_CNT = 1.
2. The payload is valid SEQ_ID, SEQ_ID value = x, low SEQ_CNT= high SEQ_CNT =SEQ_CNT of ABTS=1. A new SEQ_ID must be used in the retransmission of FCP_RESP and the SEQ_CNT value used must be one greater than the value used in the Target ABTS frame. Note that SEQ_IDs used by the Initiator and Target are completely independent of each other, x could be the same value as y in the above example.
D.5?? Class 2  ACK to FCP_CMND and FCP_RESP Lost, no FCP_CONF Req. Plus ACK lost to previous FCP_RESP

1. BA_RJT is the response since no context exists for the old Exchange. Note that the old ESB, if it existed, would look very similar to the current ESB, except for the RX_ID valid value of g and E_STAT indicating a Completion indication of complete and an Ending Condition of Normal. Note that the Target must wait R_A_TOV before releasing the Recovery Qualifier (waiting for missing ACK) for the first Exchange, to free up RX_ID=a. Note that SEQ_ID values x and y can be different values or the SAME value, but z must be different than y and j must be different than z.
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.

Change E_D_TOV in the test to 2*R_A_TOV to agree with the text 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.

Change E_D_TOV in the test to 2*R_A_TOV to agree with the text in 12.6.2
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.

The second REC is issued using a new Exchange.
D.13c Class 2, REC Response Lost

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_CNT= SEQ_CNT of ABTS. Target reissues ACC.
D.14a  Class 3, SRR Lost

Note: BA_ACC Payload: SEQ_ID Validity = invalid, low SEQ_CNT=0, high SEQ_CNT = SEQ_CNT of ABTS frame. Recovery Qualifiers are established on both sides. SRR* is issued in a new Exchange.
The Target restarts the original Exchange per the SRR* Payload.

Change E_D_TOV in the test to 2*R_A_TOV to agree with the text in 12.6.3
D.14b  Class 3, SRR Response Lost

Note: The Exchange for the SRR completed. Since to the Target this looks like an ABTS on a new Exchange, the BA_ACC Payload is SEQ_ID Validity = invalid, low SEQ_CNT=0, high SEQ_CNT = SEQ_CNT of ABTS. FCP_RJT is returned since the original Exchange has been restarted by the Target per the Payload of the SRR. The original Exchange is in process, or it has completed and no context for it (OX_ID-RX_ID) remains.

Change E_D_TOV in the test to 2*R_A_TOV to agree with the text in 12.6.3
D.14c Class 2, SRR Lost

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. The second SRR is issued using a new Exchange.
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 and a SEQ_CNT one greater than used in the ABTS.