IBM TotalStorage™ Peer-to-Peer Virtual Tape Server Failover Test Scenarios in an OS/390 Environment

An Advanced Technical Support White Paper

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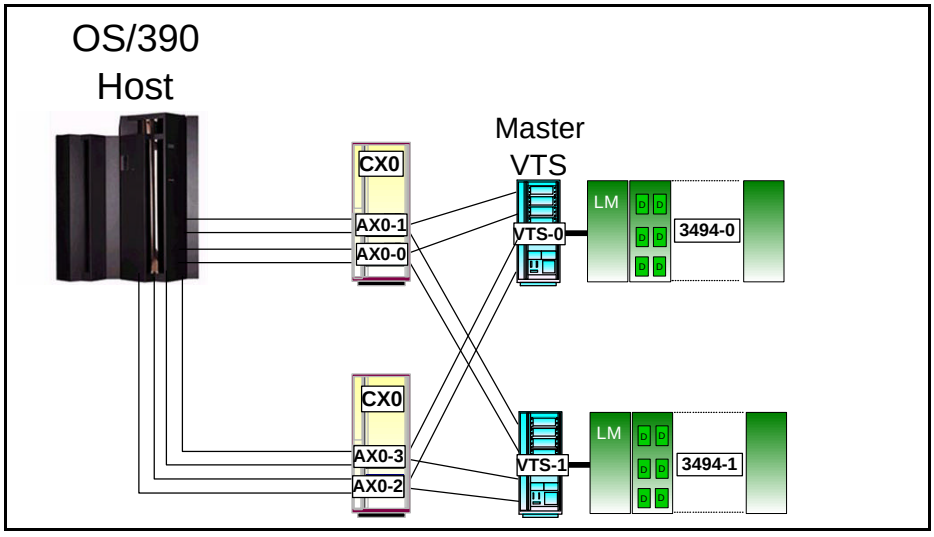
Purpose

The IBM TotalStorage™ Peer-to-Peer (PtP) Virtual Tape Server is designed so that no single component failure will result in loss of access to data. In addition, data access is also preserved during many multiple component failure situations. The complexity of the PtP VTS configuration, coupled with the large number of possible failure scenarios, has made the task of developing failover test plans a challenging one. This paper was written in an effort to assist IBM Specialists and customers in developing such plans. The paper documents a series of PtP VTS failover testing scenarios for OS/390 which were run in an IBM laboratory environment. Single failures of all major components and communication links and some multiple failures are simulated. Obviously, not all possible failover situations could be covered, but only those which demonstrate the critical hardware and microcode failover capabilities of the PtP.

Test Configuration

The hardware configuration used for the laboratory test scenarios is illustrated below. Although all the components tested were local, the results of the tests should be similar, if not the same, for remote configurations. In configurations utilizing eight AX0s, results should be consistent with the results for the test configuration. All ESCON connections were direct, but again, the results should be valid for configurations utilizing ESCON directors. Any supported level of OS/390 software, and current levels of VTS and 3494 microcode should all provide similar results. The test environment was MVS/JES2. PtP VTS failover capabilities are the same for all supported host platforms, although host messages will differ, and dynamic device recovery capabilities may not be supported in some environments.

During the laboratory tests, all virtual devices were online to the host.



IBM Service Support During Failover Testing

It is highly recommended that IBM service representatives be involved in the planning and execution of any PtP VTS failover tests. In some scenarios, CE intervention may be required to initiate failures, and/or restore "failed" components to normal operation.

Test Job Mix

The test jobs running during each of the failover scenarios consisted of 10 jobs which mounted single specific logical volumes for input (read), and 5 jobs which mounted single scratch logical volumes for output (write). The mix of work used in the tests was purely arbitrary, and any mix would be suitable, but in order for DDR to be successful, some logical drives must be available for swap, and for that reason it is recommended that less than the maximum number of virtual drives be active during testing. Also, a large number of messages are generated during some scenarios**,** and fewer jobs will reduce the number of host console messages.

PtP VTS Read Recovery Enhancements

The Peer-to-Peer VTS has improved capability to read a logical volume if a permanent media read error occurs when a logical volume is recalled from a stacked volume, or if incorrect data is detected when being transferred to the host. Recovery is achieved either transparently within the Peer-to-Peer configuration or through use of DDR by the host.

Recovery for a logical volume which has a stacked volume media error is provided by the distributed VTS and the Model AX0. The following actions are taken:

- if a recall fails due to a permanent media read error on a 3590 tape drive, the distributed VTS will retry the recall on another 3590 tape drive. Failure on the second 3590 results in the stacked volume being placed in "read-only" status. This action is the same as for a standalone VTS.
- the AX0 detects when a VTS has not been able to recall a logical volume due to a 3590 media error and changes the I/O VTS for this logical volume to the other VTS. Recall of the dual copy into the tape volume cache of the second VTS makes the logical volume available.
- if there is another media error on the second stacked volume, an Equipment Check error will occur on the first I/O operation after the Mount completion and the job will fail.

Once an hour, a VTS checks for stacked volumes which are in read-only status and recalls the logical volumes into the tape volume cache, thus removing the logical volumes from the damaged stacked volume. The Peer-to-Peer VTS enhances this process by copying logical volumes, which cannot be read, from the other VTS in a transparent manner, thus restoring two available copies. If a dual copy of the unreadable logical volume has not yet been created in the second VTS at the time of the read-only status volume recovery, the intervention required message "Logical volume xxxxxx was not fully recovered from damaged stacked volume yyyyyy" is posted to the attached hosts. An IBM service representative can initiate action for logical volumes which must be recovered.

Data from the Tape Volume Cache is checked for errors as read commands are being processed through the ESCON adapters which provide host attachment. The recovery process is:

- a read command failure causes MVS hosts to initiate the DDR process**.**
- when the logical volume is remounted, positioned and the Read command that failed is reissued, the AX0 being used will access the copy of the logical volume in the other VTS.

- a successful completion of a Rewind/Unload command causes the Peer-to-Peer VTS configuration to make a new copy of the logical volume in the VTS which originally had the failure, thereby replacing the erroneous copy and ensuring that two copies remain accessible.
- continuing failures to read the logical volume with use of the DDR process must be reported to the service representative.

Peer-to-Peer VTS Failure Mode Principles

The Peer-to-Peer VTS provides the following availability and service characteristics:

• As long as one of the AX0s remains online, only one of the distributed VTSs needs to be operational for the Peer-to-Peer VTS system to be operational. Data access during this period depends on the mode of operation prior to the failure:

- **Immediate copy mode:** Access to data written by completed jobs (successful rewind/unload) prior to the failure is maintained. Access to data of incomplete jobs that were in process at the time of the failure is not provided.
- **Deferred copy mode:** In addition to the loss of access present in the immediate copy mode, access to some portions of data written by previously completed jobs may not be possible until the failed distributed VTS is returned to service.

• If in immediate copy mode, copy operations are deferred if one of the distributed VTSs and its associated distributed library are not operational.
• When only one AX0 is operational, a second AX0 must be brought online before the first AX0 may be taken down for service.
• If all AX0s fail at the same time, both distributed VTSs must be operational to bring one of the AX0s online and restore Peer-to-Peer VTS operation.
• If both distributed VTSs fail at the same time, both must be brought up to restore normal Peer-to-Peer VTS operation.
• Changing logical volumes from the insert category to a valid category requires both distributed VTSs to be operational.
• A failure of either an AX0 or a distributed VTS may cause the jobs executing to abend. The jobs must be restarted to complete.
• Failure of a distributed VTS which is not a Master VTS will allow the Master VTS to continue writing logical volumes and reading logical volumes which have previously been closed.
• If an AX0 loses communication with the Master VTS, all the virtual tape drives associated with that AX0 will become unavailable to the host system(s).
• In the event of a failure in the Peer-to-Peer VTS where one of the AX0s can no longer communicate with the Master VTS, that AX0 will, if it has communications with the other VTS, request that the other VTS become the Master VTS. The process to change the Master VTS is called switchover.
• In a four-AX0 configuration, a Master switchover fails if there are less than three operational AX0s remaining in the Peer-to-Peer VTS or if any of the AX0s do not have communications with the non-Master VTS.
• In an eight-AX0 configuration, a Master switchover fails if there are less than five operational AX0s remaining in the Peer-to-Peer VTS or if any of the AX0s do not have communications with the non-Master VTS.

• An AX0 can be put in read-only mode or read/write disconnected mode in order to continue processing with the other AX0s. This function has to be performed by an IBM support specialist. The virtual drive addresses for the Peer-to-Peer VTS should be varied offline to perform this task. For more detail, see Appendix A.

Scenario Format

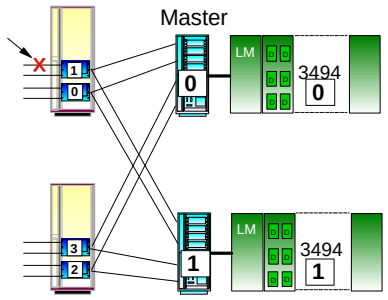
The following table format is used to document each scenario:

Scenario #	**Scenario title**
Configuration graphic, showing failed link(s) and/or component(s)	**Description:** A description of the link or component failure(s) in this scenario. **To test:** Actions required to test this scenario.
Effects of the failure: A list of the effects of the failure(s) on the Peer-to-Peer capabilities and operations.	
Messages: A list of various host console messages with paraphrased text. Messages that may be posted during this scenario are indicated with an "X".	
Recovery from actual failure: Actions required to recover from the failure(s) in this scenario. **Recovery from test:** Actions required to resume normal operations after a test of this scenario.	

Feedback

Any questions, comments, corrections, and additions are welcomed, and should be directed to: J.D. Metzger, IBM Advanced Technical Support (jdmetzg@us.ibm.com).

Single ESCON Link Failures

Failover Scenario # 1	Failure of a host link to an AX0
	**Description:** One ESCON link between the host and AX0-1 fails. It may be that the intermediate ESCON directors, ESCON channel extenders or remote channel extenders fail. **To test:** Disconnect the ESCON cable from the host to AX0-1.

Effects of the failure:

- All Peer-to-Peer VTS components continue to operate.
- Copied data remains available.
- All channel activity on the failing host link is stopped.
- Host channel errors are reported or error information becomes available from the intermediate equipment.

Messages:

Hardware:

_X_ IOS001E/IOS450E Path offline
_X_ IOS050I Channel detected error
_X_ IOS581E Link failure
___ IOS000I (and related) Data check/Equipment check/I/O error/SIM
___ IGF500I/IGF500D (and related) DDR swap
___ IGF512I (and related) Swap failure
___ IOS002A No paths available
___ IOS426I (and related) Reset allegiance failure
___ IOS104I (and related) Device boxed
___ IEF281I Device offline - boxed
___ IOS003A Intervention required
___ IEF524I/IEF525E Pending offline
___ IEF696I I/O timeout

OAM:

___ CBR3786E VTS operations degraded in library
___ CBR4195I/CBR4196D (and related) I/O error in library
___ CBR3787E Immediate mode copy operations deferred in library
___ CBR3785E Copy operations disabled in library

Failover Scenario #1 (con't)

MVS:

___ IEC215I (and related) Abend 714-0C - I/O error on close
___ IEC210I (and related) Abend 214-0C - I/O error on read
___ IEC147I (and related) Abend 613-20 - CBRXLCS processing error

Recovery from actual failure:

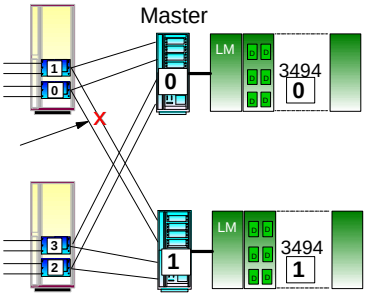
- Normal error recovery procedures and repair will apply for the ESCON channel and the intermediate equipment
- Contact your service representative for repair of the failed connection.

Recovery from test:

- Reconnect ESCON cable.

Single ESCON Link Failures (con't)

Failover Scenario # 2	Failure of the link between an AX0 and the non-Master VTS



Description:
One ESCON link between AX0-1 and VTS-1 fails. VTS-0 is the Master VTS.

To test:
Disconnect the ESCON cable from AX0-1 to VTS-1.

Effects of the failure:

- All Peer-to-Peer VTS components continue to operate.
- Copied data remains available.
- DDR is performed for the tape drive addresses for AX0-1 if they were reading logical volumes with VTS-1 as the I/O VTS. If, when DDR is performed and a tape drive address for AX0-1 is used, the job continues if a copy of the logical volume is available in VTS-0. If, when DDR is performed, a tape drive address of another AX0 is used, the job continues.
- Any jobs writing logical volumes with the tape drive addresses for AX0-1 with VTS-1 as the I/O VTS will fail and must be rerun.
- In Immediate Copy Mode, any dual copy of a logical volume in process at the time of the failure will be processed by other AX0s in the configuration as if it were a deferred copy (as workload permits).
- Logical volumes which had failure of I/O operations in process due to the failed link are made available for subsequent use by other AX0s.
- Performance degradation is possible because the remaining AX0s must handle all workload.
- Call home support is invoked.

Messages:

Hardware:

___ IOS001E/IOS450E Path offline
___ IOS050I Channel detected error
___ IOS581E Link failure
_X_ IOS000I (and related) Data check/Equipment check/I/O error/SIM
_X_ IGF500I/IGF500D (and related) DDR swap
_X_ IGF512I (and related) Swap failure
___ IOS002A No paths available
___ IOS426I (and related) Reset allegiance failure
___ IOS104I (and related) Device boxed

Failover Scenario #2 (con't)

___ IEF281I Device offline - boxed
_X_ IOS003A Intervention required
___ IEF524I/IEF525E Pending offline
___ IEF696I I/O timeout

OAM:

_X_ CBR3786E VTS operations degraded in library
_X_ CBR4195I/CBR4196D (and related) I/O error in library
___ CBR3787E Immediate mode copy operations deferred in library
___ CBR3785E Copy operations disabled in library

MVS:

_X_ IEC215I (and related) Abend 714-0C - I/O error on close
___ IEC210I (and related) Abend 214-0C - I/O error on read
___ IEC147I (and related) Abend 613-20 - CBRXLCS processing error

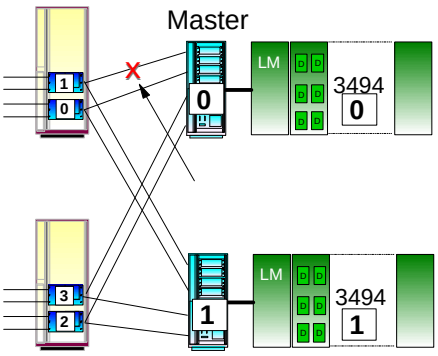
Recovery from actual failure:

- Contact your service representative for repair of the failed connection.

Recovery from test:

- Reconnect ESCON cable.

Single ESCON Link Failures (con't)

Failover Scenario # 3	Failure of the link between an AX0 and the Master VTS
	**Description:** One ESCON link between AX0-1 and VTS-0 fails. VTS-0 is the Master VTS. **To test:** Disconnect the ESCON cable from AX0-1 to VTS-0.

Effects of the failure:

- The virtual tape drive addesses for AX0-1 will become unavailable, all other Peer-to-Peer VTS components continue to operate.
- Copied data remains available.
- Master VTS switchover occurs, VTS-1 becomes the Master VTS.
- DDR is performed for the tape drive addresses for AX0-1 if they were reading logical volumes with VTS-0 as the I/O VTS. If, when DDR is performed, a tape drive address for AX0-1 is used, the DDR will fail. If, when DDR is performed, a tape drive address of another AX0 is used, the job continues.
- Any jobs writing logical volumes with the tape drive addresses for AX0-1 with VTS-0 as the I/O VTS will fail and must be rerun.
- In Immediate Copy Mode, any dual copy of a logical volume in process at the time of the failure will be processed by other AX0s in the configuration as if it were a deferred copy (as workload permits).
- Logical volumes which had a failure of I/O operations in process due to the failed link are made available for subsequent use by other AX0s.
- Performance degradation is possible because the remaining AX0s must handle all workload.
- Call home support is invoked.

Messages:

Hardware:

___ IOS001E/IOS450E Path offline
___ IOS050I Channel detected error
___ IOS581E Link failure
_X_ IOS000I (and related) Data check/Equipment check/I/O error/SIM
_X_ IGF500I/IGF500D (and related) DDR swap
_X_ IGF512I (and related) Swap failure
___ IOS002A No paths available

Failover Scenario #3 (con't)

___ IOS426I (and related) Reset allegiance failure
___ IOS104I (and related) Device boxed
___ IEF281I Device offline - boxed
_X_ IOS003A Intervention required
___ IEF524I/IEF525E Pending offline
___ IEF696I I/O timeout

OAM:

_X_ CBR3786E VTS operations degraded in library
_X_ CBR4195I/CBR4196D (and related) I/O error in library
___ CBR3787E Immediate mode copy operations deferred in library
___ CBR3785E Copy operations disabled in library

MVS:

_X_ IEC215I (and related) Abend 714-0C - I/O error on close
___ IEC210I (and related) Abend 214-0C - I/O error on read
___ IEC147I (and related) Abend 613-20 - CBRXLCS processing error

Recovery from actual failure:

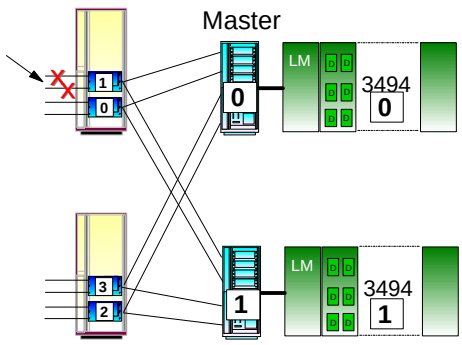
- Rerun any failed jobs.
- Contact your service representative for repair of the failed connection.

Recovery from test:

- Reconnect ESCON cable
- Switch the Master back to VTS-0 (IBM CE support required).

Note: After the failed link is restored, immediate copy mode operation is automatically resumed by AX0-1, if it was the copy mode before the failure.

Multiple ESCON Link Failures

Failover Scenario # 4	Failure of both host links to an AX0
	**Description:** Both ESCON links between the host and AX0-1 fail. **To test:** Disconnect both ESCON cables from the host to AX0-1.

Effects of the failure:

- The virtual tape drive addresses for AX0-1 will become unavailable, all other Peer-to-Peer components continue to operate.
- All channel activity on the failing host links is stopped.
- Host channel errors are reported or error information becomes available from the intermediate equipment.
- Copied data remains available.
- Jobs which were using the virtual tape drives of AX0-1 will fail.
- Logical volumes in use on AX0-1 are made available for subsequent use on other AX0s.

Messages:

Hardware:

_X_ IOS001E/IOS450E Path offline
_X_ IOS050I Channel detected error
_X_ IOS581E Link failure
_X_ IOS000I (and related) Data check/Equipment check/I/O error/SIM
___ IGF500I/IGF500D (and related) DDR swap
___ IGF512I (and related) Swap failure
_X_ IOS002A No paths available
_X_ IOS426I (and related) Reset allegiance failure
_X_ IOS104I (and related) Device boxed
_X_ IEF281I Device offline - boxed
___ IOS003A Intervention required
_X_ IEF524I/IEF525E Pending offline
_X_ IEF696I I/O timeout

Failover Scenario # 4 (con't)

OAM:

___ CBR3786E VTS operations degraded in library
_X_ CBR4195I/CBR4196D (and related) I/O error in library
___ CBR3787E Immediate mode copy operations deferred in library
___ CBR3785E Copy operations disabled in library

MVS:

_X_ IEC215I (and related) Abend 714-0C - I/O error on close
_X_ IEC210I (and related) Abend 214-0C - I/O error on read
___ IEC147I (and related) Abend 613-20 - CBRXLCS processing error

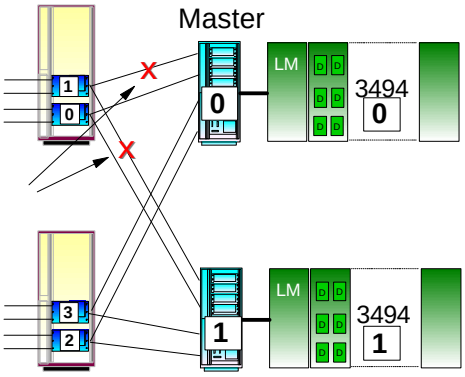
Recovery from actual failure:

- Rerun any failed jobs.
- Contact your service representative for repair of the failed connections.

Recovery from test:

- Reconnect both ESCON cables.
- Vary devices and components online from the host as required.

Multiple ESCON Link Failures (con't)

Failover Scenario #5	Failure of the links between a single AX0 and both VTSs
	**Description:** The ESCON links from AX0-1 to both VTSs fail. **To test:** Disconnect both ESCON cables from AX0-1 to VTS-0 and VTS-1.

Effects of the failure:

- If the link failure between AX0-1 and VTS-0 occurs before the link failure between AX0-1 and VTS-1, Master switchover may occur.
- The virtual tape drive addresses for AX0-1 will become unavailable, all other Peer-to-Peer VTS components continue to operate.
- Jobs using the virtual tape drives for AX0-1 will fail.
- Logical volumes in use on AX0-1 are made available for subsequent use on the other AX0s.
- Performance degradation is possible because the remaining AX0s must handle the total workload.
- Call home support is invoked.

Messages:

Hardware:

___ IOS001E/IOS450E Path offline
___ IOS050I Channel detected error
___ IOS581E Link failure
_X_ IOS000I (and related) Data check/Equipment check/I/O error/SIM
___ IGF500I/IGF500D (and related) DDR swap
_X_ IGF512I (and related) Swap failure
___ IOS002A No paths available
___ IOS426I (and related) Reset allegiance failure
_X_ IOS104I (and related) Device boxed
_X_ IEF281I Device offline - boxed
___ IOS003A Intervention required
_X_ IEF524I/IEF525E Pending offline
_X_ IEF696I I/O timeout

Failover Scenario # 5 (con't)

OAM:

_X_ CBR3786E VTS operations degraded in library
_X_ CBR4195I/CBR4196D (and related) I/O error in library
___ CBR3787E Immediate mode copy operations deferred in library
___ CBR3785E Copy operations disabled in library

MVS:

_X_ IEC215I (and related) Abend 714-0C - I/O error on close
_X_ IEC210I (and related) Abend 214-0C - I/O error on read
_X_ IEC147I (and related) Abend 613-20 - CBRXLCS processing error

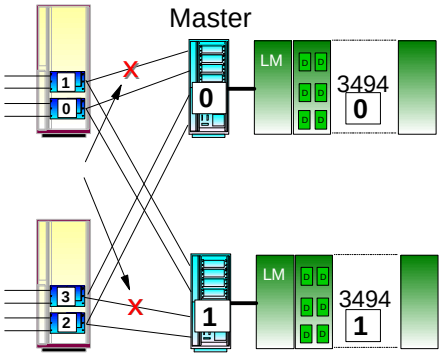
Recovery from actual failure:

- Rerun any failed jobs.
- Contact your service representative for repair of the failed connections.

Recovery from test:

- Reconnect both ESCON cables.
- Vary devices and components online from the host as required.

Multiple ESCON Link Failures (con't)

Failover Scenario # 6	Failure of links between 2 AX0s and both VTSs
	**Description:** The ESCON link between AX0-1 and VTS-0 and the ESCON link between AX0-3 and VTS-1 fail. VTS-0 is the Master VTS. **To test:** Disconnect the ESCON cable from AX0-1 to VTS-0 *and* Disconnect the ESCON cable from AX0-3 to VTS-1.

Effects of the failure:

- The virtual addresses for AX0-1 will become unavailable, all other Peer-to-Peer components continue to operate.
- Copied data remains available.
- Master VTS switchover fails.
- DDR is performed for the tape drive addresses for AX0-1 if they were reading logical volumes with VTS-0 as the I/O VTS. If, when DDR is performed, a tape drive address for AX0-1 is used, the DDR will fail. If, when DDR is performed, a tape drive address for another AX0 is used, the job continues.
- DDR is performed for the tape drive addresses for AX0-3 if they were reading logical volumes with VTS-1 as the I/O VTS. If, when DDR is performed, a tape drive address for AX0-1 is used, the DDR will fail. If, when DDR is performed, a tape drive address for AX0-2 or AX0-4 is used, the job continues. If, when DDR is performed, a tape drive address for AX0-3 is used, the job continues only if a copy of the logical volume is available in VTS-0.
- Any jobs writing logical volumes with the tape drive addresses for AX0-1 with VTS-0 as the I/O VTS will fail and must be rerun.
- Any jobs writing logical volumes with the tape drive addresses for AX0-3 with VTS-1 as the I/O VTS will fail and must be rerun.
- In Immediate Copy Mode, any dual copy of a logical volume in process at the time of the failure will be processed by other AX0s in the configuration as if it were a deferred copy (as workload permits).
- Logical volumes which had failure of I/O operations in process due to the failed link are made available for subsequent use by other AX0s.
- Performance degradation is possible because the remaining AX0s must handle all workload.
- Call home support is invoked.

Failover Scenario # 6 (con't)

Messages:

Hardware:

___ IOS001E/IOS450E Path offline
___ IOS050I Channel detected error
___ IOS581E Link failure
_X_ IOS000I (and related) Data check/Equipment check/I/O error/SIM
_X_ IGF500I/IGF500D (and related) DDR swap
___ IGF512I (and related) Swap failure
___ IOS002A No paths available
___ IOS426I (and related) Reset allegiance failure
_X_ IOS104I (and related) Device boxed
_X_ IEF281I Device offline - boxed
_X_ IOS003A Intervention required
___ IEF524I/IEF525E Pending offline
_X_ IEF696I I/O timeout

OAM:

___ CBR3786E VTS operations degraded in library
_X_ CBR4195I/CBR4196D (and related) I/O error in library
___ CBR3787E Immediate mode copy operations deferred in library
___ CBR3785E Copy operations disabled in library

MVS:

_X_ IEC215I (and related) Abend 714-0C - I/O error on close
___ IEC210I (and related) Abend 214-0C - I/O error on read
___ IEC147I (and related) Abend 613-20 - CBRXLCS processing error

Recovery from actual failure:

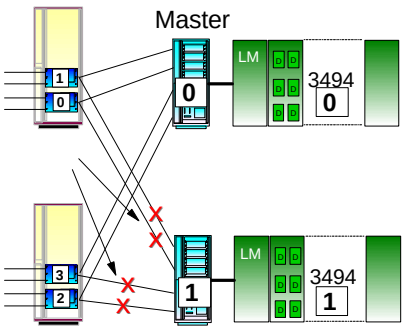
- Rerun any failed jobs.
- Contact your service representative for repair of the failing connections.

Recovery from test:

- Reconnect ESCON cables.
- Vary devices and components online from the host as required.

Note: After the failed links are repaired, immediate copy mode operation is automatically resumed by the AX0s which had a failed link, if it was the copy mode before the failure.

Multiple ESCON Link Failures (con't)

Failover Scenario # 7	Failure of all links to the non-Master VTS
	**Description:** All ESCON links between the AX0s and VTS-1 fail. VTS-0 is the Master VTS. **To test:** Disconnect the ESCON cables to VTS-1.

Effects of the failure:

- All Peer-to-Peer components continue to operate.
- Copied data remains available.
- Logical volumes in VTS-1 which have not been copied will not be available.
- If in Immediate Copy Mode, the dual copy of logical volumes will be deferred.
- DDR is performed for tape drive addresses which were reading logical volumes with VTS-1 as the I/O VTS. When DDR is performed, the job will continue if a copy of the logical volume is available in VTS-0.
- Any jobs writing logical volumes with VTS-1 as the I/O VTS will fail and must be rerun.
- Logical volumes which had failure of I/O operations in process due to the failed links are made available for subsequent use by other AX0s.
- Performance degradation is possible because only one VTS must handle the total workload.
- Insert or eject of logical volumes is not possible.
- Preferencing is bypassed for AX0s which were preferencing VTS-1.
- Call home support is invoked.

Messages:

Hardware:

___ IOS001E/IOS450E Path offline
___ IOS050I Channel detected error
___ IOS581E Link failure
_X_ IOS000I (and related) Data check/Equipment check/I/O error/SIM
_X_ IGF500I/IGF500D (and related) DDR swap
_X_ IGF512I (and related) Swap failure
___ IOS002A No paths available
___ IOS426I (and related) Reset allegiance failure

Failover Scenario # 7 (con't)

___ IOS104I (and related) Device boxed
___ IEF281I Device offline - boxed
_X_ IOS003A Intervention required
___ IEF524I/IEF525E Pending offline
_X_ IEF696I I/O timeout

OAM:

_X_ CBR3786E VTS operations degraded in library
_X_ CBR4195I/CBR4196D (and related) I/O error in library
_X_ CBR3787E Immediate mode copy operations deferred in library
_X_ CBR3785E Copy operations disabled in library

MVS:

_X_ IEC215I (and related) Abend 714-0C - I/O error on close
___ IEC210I (and related) Abend 214-0C - I/O error on read
___ IEC147I (and related) Abend 613-20 - CBRXLCS processing error

Recovery from actual failure:

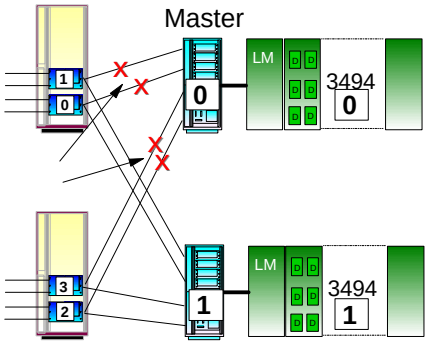
- Rerun any failed jobs.
- Contact your service representative for repair of the failed connections.

Recovery from test:

- Reconnect ESCON cables.

Note: After the failed links are repaired, immediate copy mode operation is automatically resumed by all AX0s, if it was the copy mode before the failure. This starts the copy operations for the deferred copies and will impact the bandwidth for data between the host and the Peer-to-Peer VTS if there is a large backlog of copies to be made.

Multiple ESCON Link Failures (con't)

Failover Scenario # 8	Failure of all links to the Master VTS
	**Description:** All ESCON links between the AX0s and VTS-0 fail. VTS-0 is the Master VTS. **To test:** Disconnect the ESCON cables to VTS-0.

Effects of the failure:

- All Peer-to-Peer components continue to operate.
- Copied data remains available.
- Master VTS switchover occurs, VTS-1 becomes the Master VTS.
- Logical volumes in VTS-0 which have not been copied will not be available.
- If in Immediate Copy Mode, the dual copy of logical volumes will be deferred.
- DDR is performed for tape drive addresses which were reading logical volumes with VTS-0 as the I/O VTS. When DDR is performed, the job will continue if a copy of the logical volume is available in VTS-1.
- Any jobs writing logical volumes with VTS-0 as the I/O VTS will fail and must be rerun.
- Logical volumes which had failure of I/O operations in process due to the failed links are made available for subsequent use by other AX0s.
- Performance degradation is possible because only one VTS must handle the total workload.
- Insert of new logical volumes is not possible.
- Preferencing is bypassed for AX0s which were preferencing VTS-0.
- Call home support is invoked.

Messages:

Hardware:

___ IOS001E/IOS450E Path offline
___ IOS050I Channel detected error
___ IOS581E Link failure
_X_ IOS000I (and related) Data check/Equipment check/I/O error/SIM
_X_ IGF500I/IGF500D (and related) DDR swap
_X_ IGF512I (and related) Swap failure
___ IOS002A No paths available

Failover Scenario # 8 (con't)

___ IOS426I (and related) Reset allegiance failure
___ IOS104I (and related) Device boxed
___ IEF281I Device offline - boxed
_X_ IOS003A Intervention required
___ IEF524I/IEF525E Pending offline
_X_ IEF696I I/O timeout

OAM:

_X_ CBR3786E VTS operations degraded in library
_X_ CBR4195I/CBR4196D (and related) I/O error in library
_X_ CBR3787E Immediate mode copy operations deferred in library
_X_ CBR3785E Copy operations disabled in library

MVS:

_X_ IEC215I (and related) Abend 714-0C - I/O error on close
___ IEC210I (and related) Abend 214-0C - I/O error on read
___ IEC147I (and related) Abend 613-20 - CBRXLCS processing error

Recovery from actual failure:

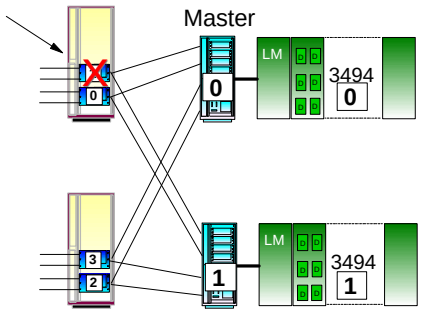
- Rerun any failed jobs.
- Contact your service representative for repair of the failed links.

Recovery from test:

- Reconnect ESCON cables.
- Switch the Master back to VTS-0 (IBM CE support required).

Note: After the failed links are restored, immediate copy mode operation is automatically resumed by all AX0s, if it was the copy mode before the failure. This starts the copy operations for the deferred copies and will impact the bandwidth for data between the host and the Peer-to-Peer VTS if there is a large backlog of copies to be made.

Peer-to-Peer Component Failures

Failover Scenario # 9	Failure of an AX0
	**Description:** AX0-1 stops processing. **To test:** Power off AX0-1 (IBM CE support required) *or* Disconnect all ESCON cables to and from AX0-1.

Effects of the failure:

- The virtual tape drive addresses for AX0-1 will become unavailable, all other Peer-to-Peer VTS components continue to operate.
- Jobs using the virtual tape drives for AX0-1 will fail.
- Logical volumes in use on AX0-1 are made available for subsequent use on the other AX0s.
- Performance degradation is possible because the remaining AX0s must handle the total workload.
- Call home support is invoked.

Messages:

Hardware:

___ IOS001E/IOS450E Path offline
___ IOS050I Channel detected error
___ IOS581E Link failure
___ IOS000I (and related) Data check/Equipment check/I/O error/SIM
___ IGF500I/IGF500D (and related) DDR swap
___ IGF512I (and related) Swap failure
___ IOS002A No paths available
___ IOS426I (and related) Reset allegiance failure
_X_ IOS104I (and related) Device boxed
_X_ IEF281I Device offline - boxed
___ IOS003A Intervention required
_X_ IEF524I/IEF525E Pending offline
_X_ IEF696I I/O timeout

OAM:

_X_ CBR3786E VTS operations degraded in library

Failover Scenario # 9 (con't)

_X_ CBR4195I/CBR4196D (and related) I/O error in library
___ CBR3787E Immediate mode copy operations deferred in library
___ CBR3785E Copy operations disabled in library

MVS:

_X_ IEC215I (and related) Abend 714-0C - I/O error on close
_X_ IEC210I (and related) Abend 214-0C - I/O error on read
___ IEC147I (and related) Abend 613-20 - CBRXLCS processing error

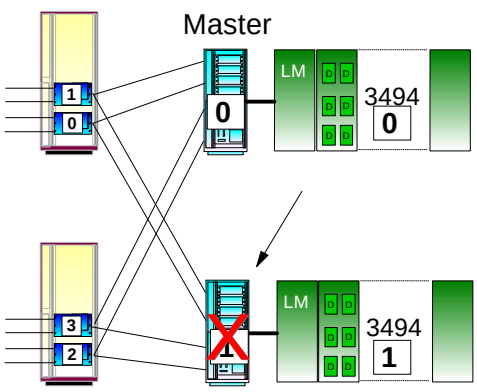
Recovery from actual failure:

- Rerun any failed jobs.
- Contact your service representative for repair of the failed AX0.

Recovery from test:

- Power on AX0 (IBM CE support required).
- Vary devices and components online from the host as required.

Peer-to-Peer Component Failures (con't)

Failover Scenario # 10	Failure of the non-Master VTS
	**Description:** VTS-1 fails. VTS-0 is the Master VTS. **To test:** Take VTS-1 offline using VTS SMIT menu - 'Force CU Offline' (IBM CE support required) Note: at the host, the effects for this scenario are the same as for scenario #7

Effects of the failure:

- All remaining Peer-to-Peer components continue to operate.
- Copied data remains available.
- Logical volumes in VTS-1 which have not been copied will not be available.
- If in Immediate Copy Mode, the dual copy of logical volumes will be deferred.
- DDR is performed for tape drive addresses which were reading logical volumes with VTS-1 as the I/O VTS. When DDR is performed, the job will continue if a copy of the logical volume is available in VTS-0.
- Any jobs writing logical volumes with VTS-1 as the I/O VTS will fail and must be rerun.
- Logical volumes which had failure of I/O operations in process due to the failed VTS are made available for subsequent use by other AX0s.
- Performance degradation is possible because only one VTS must handle the total workload.
- Insert or eject of logical volumes is not possible.
- Preferencing is bypassed for AX0s which were preferencing VTS-1.
- Call home support is invoked.

Messages:

Hardware:

___ IOS001E/IOS450E Path offline
___ IOS050I Channel detected error
___ IOS581E Link failure
_X_ IOS000I (and related) Data check/Equipment check/I/O error/SIM
_X_ IGF500I/IGF500D (and related) DDR swap
_X_ IGF512I (and related) Swap failure
___ IOS002A No paths available

Failover Scenario # 10 (con't)

___ IOS426I (and related) Reset allegiance failure
___ IOS104I (and related) Device boxed
___ IEF281I Device offline - boxed
_X_ IOS003A Intervention required
___ IEF524I/IEF525E Pending offline
_X_ IEF696I I/O timeout

OAM:

_X_ CBR3786E VTS operations degraded in library
___ CBR4195I/CBR4196D (and related) I/O error in library
_X_ CBR3787E Immediate mode copy operations deferred in library
_X_ CBR3785E Copy operations disabled in library

MVS:

_X_ IEC215I (and related) Abend 714-0C - I/O error on close
___ IEC210I (and related) Abend 214-0C - I/O error on read
___ IEC147I (and related) Abend 613-20 - CBRXLCS processing error

Recovery from actual failure:

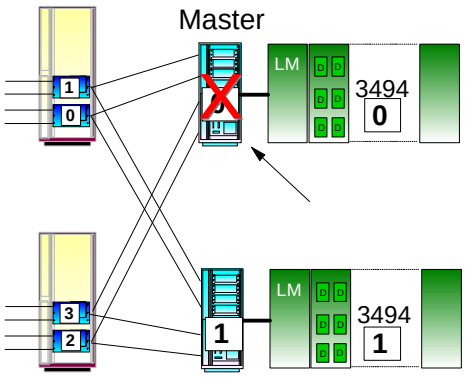
- Rerun any failed jobs.
- Contact your service representative for repair of the failed VTS.

Recovery from test:

- Bring VTS online (IBM CE support required).

Note: After the failed VTS is restored to service, immediate copy mode operation is automatically resumed by all AX0s if it was the copy mode before the failure. This starts the copy operations for the deferred copies and will impact the bandwidth for data between the host and the Peer-to-Peer VTS if there is a large backlog of copies to be made.

Peer-to-Peer Component Failures (con't)

Failover Scenario # 11	Failure of the Master VTS
	**Description:** VTS-0 fails. VTS-0 is the Master VTS. **To test:** Take VTS-0 offline using VTS SMIT menu - 'Force CU Offline' (IBM CE support required) Note: at the host, the effects for this scenario are the same as for scenario #8.

Effects of the failure:

- All remaining Peer-to-Peer components continue to operate.
- Copied data remains available.
- Master VTS switchover occurs, VTS-1 becomes the Master VTS.
- Logical volumes in VTS-0 which have not been copied will not be available.
- If in Immediate Copy Mode, the dual copy of logical volumes will be deferred.
- DDR is performed for tape drive addresses which were reading logical volumes with VTS-0 as the I/O VTS. When DDR is performed, the job will continue if a copy of the logical volume is available in VTS-1.
- Any jobs writing logical volumes with VTS-0 as the I/O VTS will fail and must be rerun.
- Logical volumes which had failure of I/O operations in process due to the failed VTS are made available for subsequent use by other AX0s.
- Performance degradation is possible because only one VTS must handle the total workload.
- Insert or eject of logical volumes is not possible.
- Preferencing is bypassed for AX0s which were preferencing VTS-0.
- Call home support is invoked.

Messages:

Hardware:

___ IOS001E/IOS450E Path offline
___ IOS050I Channel detected error
___ IOS581E Link failure
_X_ IOS000I (and related) Data check/Equipment check/I/O error/SIM
_X_ IGF500I/IGF500D (and related) DDR swap
_X_ IGF512I (and related) Swap failure

Failover Scenario # 11 (con't)

___ IOS002A No paths available
___ IOS426I (and related) Reset allegiance failure
___ IOS104I (and related) Device boxed
___ IEF281I Device offline - boxed
_X_ IOS003A Intervention required
___ IEF524I/IEF525E Pending offline
_X_ IEF696I I/O timeout

OAM:

_X_ CBR3786E VTS operations degraded in library
___ CBR4195I/CBR4196D (and related) I/O error in library
_X_ CBR3787E Immediate mode copy operations deferred in library
_X_ CBR3785E Copy operations disabled in library

MVS:

_X_ IEC215I (and related) Abend 714-0C - I/O error on close
___ IEC210I (and related) Abend 214-0C - I/O error on read
___ IEC147I (and related) Abend 613-20 - CBRXLCS processing error

Recovery from actual failure:

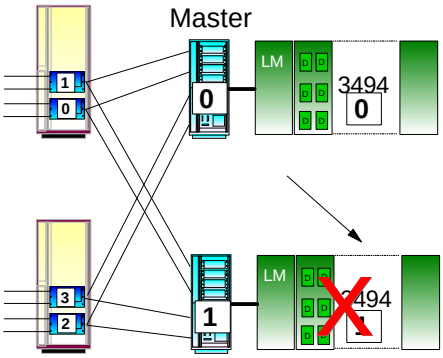
- Rerun any failed jobs.
- Contact your service representative for repair of the failed VTS.

Recovery from test:

- Bring VTS online (IBM CE support required).
- Switch the Master back to VTS-0 (IBM CE support required).

Note: After the failed VTS is restored to service, immediate copy mode operation is automatically resumed by all AX0s if it was the copy mode before the failure. This starts the copy operations for the deferred copies and will impact the bandwidth for data between the host and the Peer-to-Peer VTS if there is a large backlog of copies to be made.

Peer-to-Peer Component Failures (con't)

Failover Scenario # 12	Failure of the 3494 attached to the non-Master VTS
	**Description:** 3494-1 fails. VTS-0 is the Master VTS. **To test:** Take 3494-1 Library Manager offline using 3494-1 Library Manager Service menu - 'Force Check1' (IBM CE support rquired).

Effects of the failure:

- All remaining Peer-to-Peer components continue to operate.
- Copied data remains available.
- VTS I/O operations in process will continue. Upon completion of operations in process, use of VTS-1 will be discontinued by all AX0s.
- The mount of a logical volume which has no copy in the cache of VTS-0 or on a stacked volume in 3494-0 will fail.
- If in Immediate Copy Mode, the dual copy of logical volumes will be deferred.
- Performance degradation is possible because only one VTS must handle the total workload.
- Insert or eject of logical volumes is not possible.
- Preferencing is bypassed for AX0s which were preferencing VTS-1.
- Call home support is invoked.

Messages:

Hardware:

___ IOS001E/IOS450E Path offline
___ IOS050I Channel detected error
___ IOS581E Link failure
___ IOS000I (and related) Data check/Equipment check/I/O error/SIM
___ IGF500I/IGF500D (and related) DDR swap
___ IGF512I (and related) Swap failure
___ IOS002A No paths available
___ IOS426I (and related) Reset allegiance failure
___ IOS104I (and related) Device boxed
___ IEF281I Device offline - boxed
___ IOS003A Intervention required

Failover Scenario # 12 (con't)

___ IEF524I/IEF525E Pending offline
___ IEF696I I/O timeout

OAM:

_X_ CBR3786E VTS operations degraded in library
___ CBR4195I/CBR4196D (and related) I/O error in library
_X_ CBR3787E Immediate mode copy operations deferred in library
_X_ CBR3785E Copy operations disabled in library

MVS:

___ IEC215I (and related) Abend 714-0C - I/O error on close
___ IEC210I (and related) Abend 214-0C - I/O error on read
___ IEC147I (and related) Abend 613-20 - CBRXLCS processing error

Recovery from actual failure:

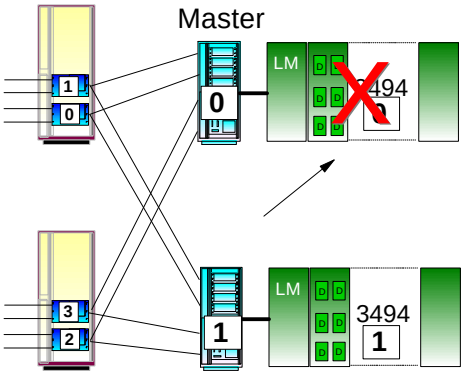
- Rerun any failed jobs.
- Contact your service representative for repair of the failed 3494.

Recovery from test:

- Bring 3494 Library Manager online (IBM CE support required).

Note: After the failed tape library is reconnected, immediate copy mode is automatically resumed by all AX0s if it was the copy mode before the failure. This starts the copy operations for the deferred copies and will impact the bandwidth for data between the host and the Peer-to-Peer VTS if there is a large backlog of copies to be made.

Peer-to-Peer Component Failures (con't)

Failover Scenario # 13	Failure of the 3494 attached to the Master VTS
	**Description:** 3494-0 fails. The Master VTS-0 is associated with 3494-0. **To test:** Take 3494-0 Library Manager offline using 3494-0 Library Manager Service menu - 'Force Check1' (IBM CE support rquired).

Effects of the failure:

- All remaining Peer-to-Peer components continue to operate.
- Copied data remains available.
- Master VTS switchover occurs, VTS-1 becomes the Master VTS.
- VTS I/O operations in process will continue. Upon completion of operations in process, use of VTS-0 will be discontinued by all AX0s.
- The mount of a logical volume which has no copy in the cache of VTS-1 or on a stacked volume in 3494-1 will fail.
- If in Immediate Copy Mode, the dual copy of logical volumes will be deferred.
- Performance degradation is possible because only one VTS must handle the total workload.
- Insert or eject of logical volumes is not possible.
- Preferencing is bypassed for AX0s which were preferencing VTS-0.
- Call home support is invoked.

Messages:

Hardware:

___ IOS001E/IOS450E Path offline
___ IOS050I Channel detected error
___ IOS581E Link failure
___ IOS000I (and related) Data check/Equipment check/I/O error/SIM
___ IGF500I/IGF500D (and related) DDR swap
___ IGF512I (and related) Swap failure
___ IOS002A No paths available
___ IOS426I (and related) Reset allegiance failure
___ IOS104I (and related) Device boxed

Failover Scenario # 13 (con't)

___ IEF281I Device offline - boxed
___ IOS003A Intervention required
___ IEF524I/IEF525E Pending offline
___ IEF696I I/O timeout

OAM:

_X_ CBR3786E VTS operations degraded in library
___ CBR4195I/CBR4196D (and related) I/O error in library
_X_ CBR3787E Immediate mode copy operations deferred in library
_X_ CBR3785E Copy operations disabled in library

MVS:

___ IEC215I (and related) Abend 714-0C - I/O error on close
___ IEC210I (and related) Abend 214-0C - I/O error on read
___ IEC147I (and related) Abend 613-20 - CBRXLCS processing error

Recovery from actual failure:

- Rerun any failed jobs.
- Contact your service representative for repair of the failed 3494.

Recovery from test:

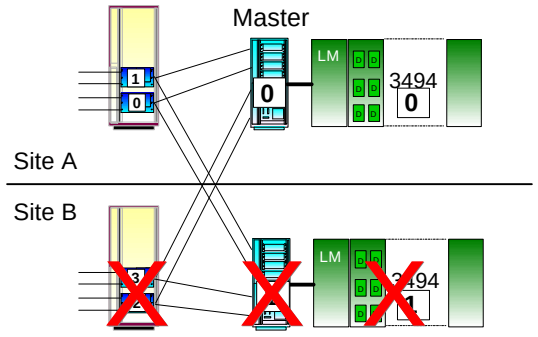
- Bring 3494 Library Manager online (IBM CE support required).
- Switch the Master back to VTS-0 (IBM CE support required).

Note: After the failed tape library is restored to service, immediate copy mode is automatically resumed by all AX0s if it was the copy mode before the failure. This starts the copy operations for the deferred copies and will impact the bandwidth for data between the host and the Peer-to-Peer VTS if there is a large backlog of copies to be made.

Peer-to-Peer Component Failures (con't)

Failover Scenario # 14

Failure of all components at the site with the non-Master VTS



Description:
All the Peer-to-Peer components at Site B fail. VTS-0 at Site A is the Master VTS.

To test:
Disconnect all ESCON cables to/from AX0-2 and AX0-3
and
Disconnect ESCON cables from AX0-0 and AX0-1 to VTS-1

Effects of the failure:

- All remaining Peer-to-Peer VTS components continue to operate.
- Copied data remains available.
- All channel activity on the failing host links are stopped.
- Host channel errors are reported or error information becomes available from the intermediate equipment.
- The virtual tape drive addresses for AX0-2 and AX0-3 will become unavailable.
- Logical volumes in VTS-1 which have not been copied will not be available.
- Jobs using the virtual tape drives for AX0-2 and AX0-3 will fail.
- Logical volumes which had failure of I/O operations in process due to the failed AX0 are made available for subsequent use by other AX0s.
- Performance degradation is possible because the remaining site must handle the total workload.
- Insert or eject of logical volumes is not possible.
- Call home support is invoked.

Messages:

Hardware:

_X_ IOS001E/IOS450E Path offline
_X_ IOS050I Channel detected error
_X_ IOS581E Link failure
_X_ IOS000I (and related) Data check/Equipment check/I/O error/SIM
___ IGF500I/IGF500D (and related) DDR swap
___ IGF512I (and related) Swap failure
_X_ IOS002A No paths available
_X_ IOS426I (and related) Reset allegiance failure

Failover Scenario # 14 (con't)

_X_ IOS104I (and related) Device boxed
_X_ IEF281I Device offline - boxed
___ IOS003A Intervention required

_X_ IEF524I/IEF525E Pending offline
_X_ IEF696I I/O timeout

OAM:

_X_ CBR3786E VTS operations degraded in library
_X_ CBR4195I/CBR4196D (and related) I/O error in library
_X_ CBR3787E Immediate mode copy operations deferred in library
_X_ CBR3785E Copy operations disabled in library

MVS:

_X_ IEC215I (and related) Abend 714-0C - I/O error on close
_X_ IEC210I (and related) Abend 214-0C - I/O error on read
___ IEC147I (and related) Abend 613-20 - CBRXLCS processing error

Recovery from actual failure:

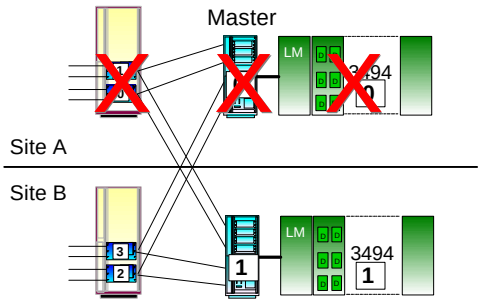
- Rerun any failed jobs.
- Contact your service representative for repair of the components at the failed site.

Recovery from test

- Reconnect all ESCON cables.
- Vary devices and components online from the host as required.

Note: After the failed components are restored to service, immediate copy mode is automatically resumed by all AX0s if it was the copy mode before the failure. This starts the copy operations for the deferred copies and will impact the bandwidth for data between the host and the Peer-to-Peer VTS if there is a large backlog of copies to be made.

Peer-to-Peer Component Failures (con't)

Failover Scenario # 15	Failure of all components at the site with the Master VTS
	**Description:** All the Peer-to-Peer components at Site A fail. The VTS at Site A is the Master VTS. **To test:** Disconnect all ESCON cables to/from AX0-0 and AX0-1 *and* Disconnect ESCON cables from AX0-2 and AX0-3 to VTS-0

Effects of the failure:

- Master switchover fails.
- I/O operations in process on AX0-2 and AX0-3 with VTS-1 as the I/O VTS will complete.
- All further processing is stopped.
- All virtual tape drive addresses will become unavailable.
- Call home support is invoked.

Messages:

Hardware:

_X_ IOS001E/IOS450E Path offline
_X_ IOS050I Channel detected error
_X_ IOS581E Link failure
_X_ IOS000I (and related) Data check/Equipment check/I/O error/SIM
___ IGF500I/IGF500D (and related) DDR swap
___ IGF512I (and related) Swap failure
_X_ IOS002A No paths available
_X_ IOS426I (and related) Reset allegiance failure
_X_ IOS104I (and related) Device boxed
_X_ IEF281I Device offline - boxed
___ IOS003A Intervention required
___ IEF524I/IEF525E Pending offline
_X_ IEF696I I/O timeout

OAM:

_X_ CBR3786E VTS operations degraded in library
_X_ CBR4195I/CBR4196D (and related) I/O error in library
_X_ CBR3787E Immediate mode copy operations deferred in library
_X_ CBR3785E Copy operations disabled in library

Failover Scenario # 15 (con't)

MVS:

_X_ IEC215I (and related) Abend 714-0C - I/O error on close
_X_ IEC210I (and related) Abend 214-0C - I/O error on read
___ IEC147I (and related) Abend 613-20 - CBRXLCS processing error

Recovery from actual failure:

- Contact your service representative for repair of the failed components at Site A.
- Consider operation of the remaining Site B components in the special AX0 operational modes available (Read/Write Disconnected or Read Only). These modes can only be activated by the IBM product support specialists. See **Appendix A** for a more detailed discussion.

Recovery from test:

- Reconnect all ESCON cables.
- Vary devices and components online as from the host required.

Appendix A

AX0 Virtual Tape Controller Special Operational Modes

The loss of multiple components of a Peer-to-Peer VTS, such as a catastrophic disaster or extended service outage, can result in failure to continue normal operations or too few components in the configuration to restore operation.

An IBM product specialist can, in exceptional circumstances, override the normal minimum configuration requirement to allow operation with one VTS and a minimum of one AX0. There are two special operational modes that may be chosen:

Read/write disconnected mode
Logical volumes may be read, modified or rewritten unless the volumes are known not to be valid. This mode may only be set for one VTS; even if all links between two sites have been lost, you must not operate both sites in read/write disconnected mode. When the second VTS is brought back into the configuration, the AX0s will then reconcile tokens, resume normal operations and schedule logical volume copies.

Read-only mode
Logical volumes may be read unless they are known not to be valid. The host is prevented from writing to the volumes or from changing their category assignment (for example, private, scratch or insert). After other components have been repaired or made accessible, the virtual drive addresses currently being used must be taken offline again before discontinuing read-only mode.

These modes can only be activated by the IBM product support specialists, for example, in cases when, after a complete shutdown of the Peer-to-Peer VTS, only one VTS can be brought back online, or if all AX0s are in the master-disabled state. All the virtual drive addresses must be varied offline at the host systems before read-only or read/write disconnected mode may be set.