SCSI-3 Exception Recovery

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- In a non-interlocked bus, the potential for out-of-order command execution exists whenever:
  - More than one command may be in transit at any time.
  - A command completes with an exception status.
  - The exception condition is removed before (or upon) the arrival of subsequent in-transit commands.
- Examples:
  - A Contingent Allegiance conditions occurs (ala SCSI-2 CA),
    - Subsequent command in-transit is executed (automatically clearing the CA).
  - A command terminates with BUSY status.
    - The BUSY condition may be cleared spontaneously.
    - Subsequent commands in-transit may be executed.

- Goals
  - Prevent a command exception from causing out-of-order command execution,
  - Must be backwards compatible with current ACA mechanism,
  - Compatible with existing SCSI-2 device drivers,
    - If driver is written to be independent of the interconnect.
  - Recovery from all 'non ACA' exceptions is hidden in protocol layer and compatible with SCSI-2 (as seen by the application client).
  - Recovery from Contingent Allegiance is compatible with SCSI-2 (as seen by the application client).
- Proposal:
  - Extend ACA mechanism to handle all exceptions.

What's Different?

StorageWorks

- A command exception exists whenever a command completes with one of the following statuses:
  - ACA or CA conditions
    - CHECK CONDITION
    - COMMAND TERMINATED
  - Command Fault conditions
    - BUSY
    - RESERVATION CONFLICT
    - EXCEPTION ACTIVE (aka "ACA ACTIVE")
    - QUEUE FULL
- Except for sense data, all exceptions have the same basic behavior as ACA.
- The faulting initiator must explicitely remove all exception conditions using CLEAR EXCEPTION (was CLEAR ACA).
- The above functions are mandatory for all non-interlocked protocol implementations.

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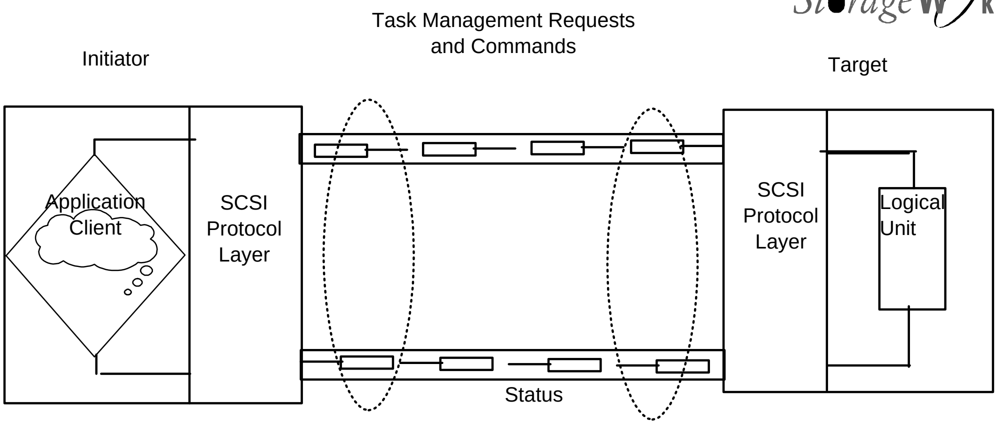
Exception Handling

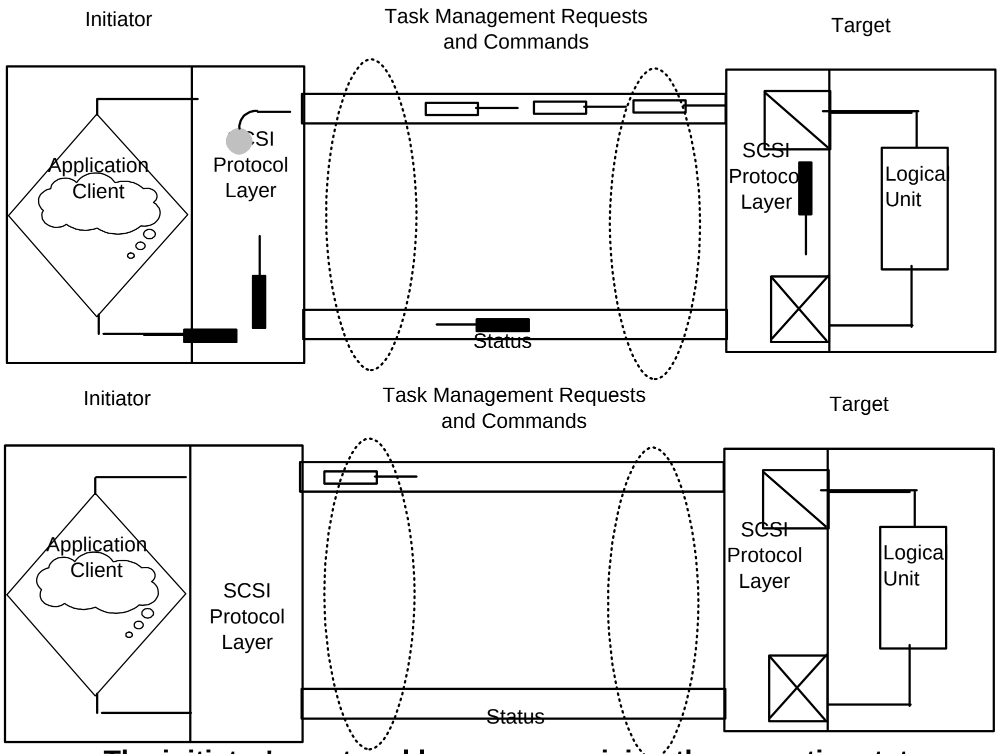
- When an exception condition occurs the target:
    - Blocks further commands from entering the task set from any initiator.
    - Blocks the return of further statuses from the logical unit to all initiators.
  - The condition must be cleared by the faulted initiator (via a CLEAR EXCEPTION request).
- When the initiator's protocol layer detects the exception it:
  - Stops sending further commands to the logical unit.
  - Flushes all in-transit commands if CA or command fault.
  - Marks all flushed commands for resend.
  - Passes the exception status to the application client.
  - Performs recovery based on exception type.

Exception Recovery Examples



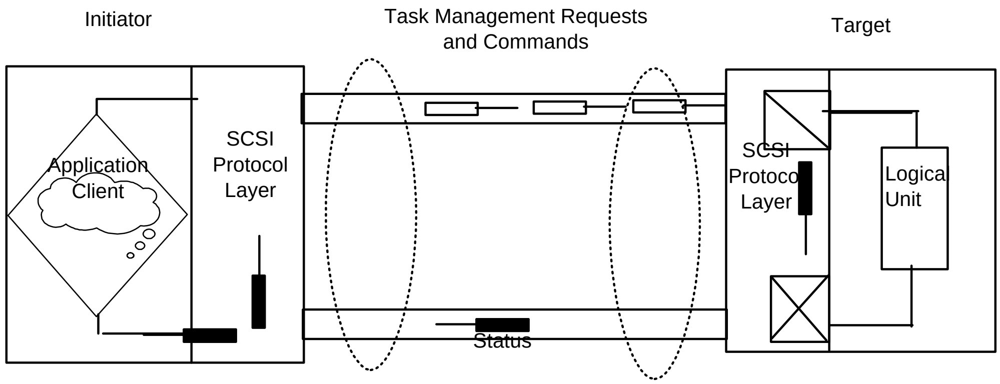
- Assumptions
  - Initiator's protocol layer retains lists of pendingcommands in the order they were sent by theapplication clients.
    - List of commands waiting to be sent.
    - List of commands that have been sent.
  - A command is removed from the appropriate list:
    - When status is received,
    - When the command is aborted. by the applicationclient.

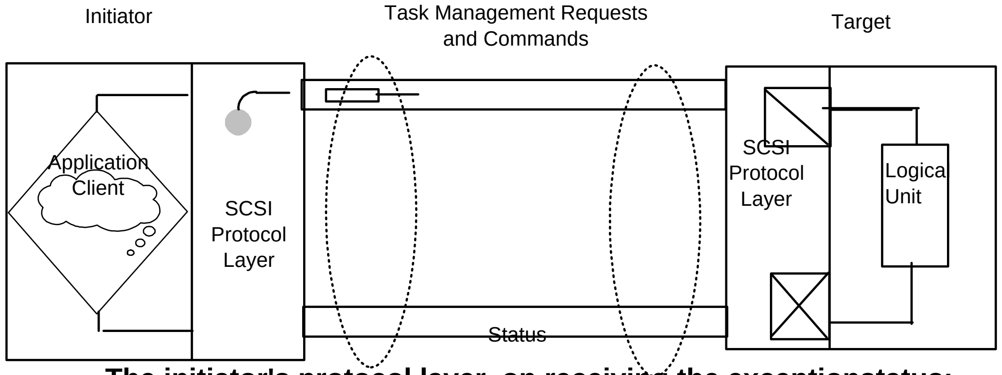
Command Fault Recovery and Contingent Allegiance with Autosense



- The initiator's protocol layer, on receiving the exceptionstatus:
  - Passes the exception status to the application client.
  - Stops sending commands to the faulted LUN.
  - Flushes in-transit commands.
    - Procedure is protocol-specific.
  - Marks flushed commands for resend.
  - Sends CLEAR EXCEPTION request
- Resends marked commands when requestedby application client.

Contingent Allegiance Recovery (No Autosense)



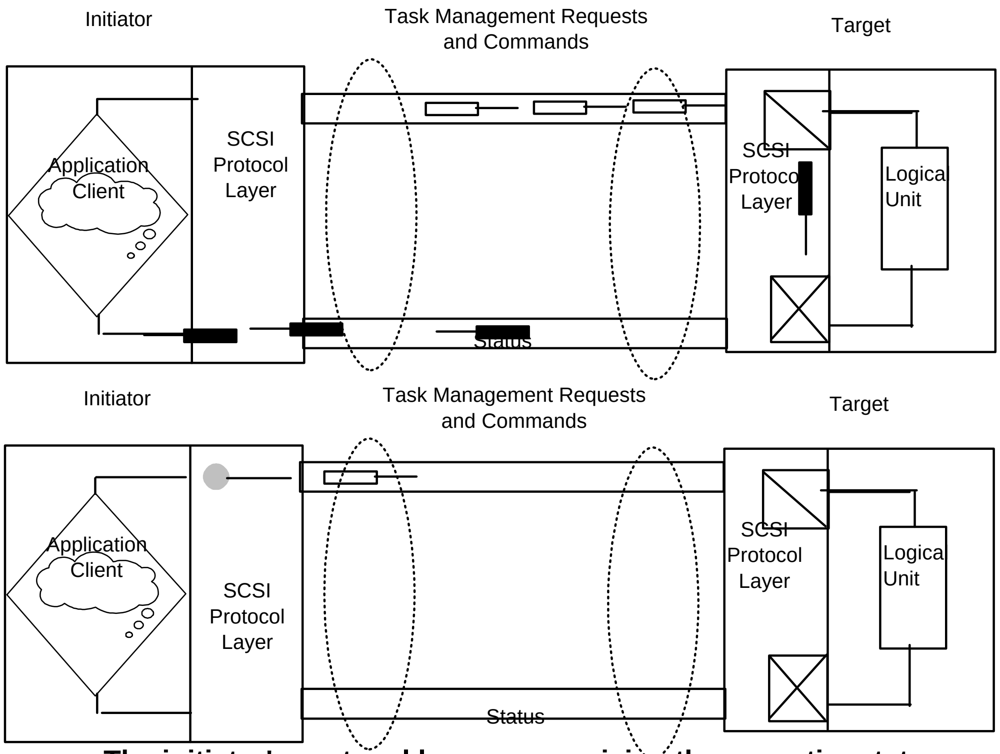


- The initiator's protocol layer, on receiving the exceptionstatus:
  - Passes the exception status to the application client.
  - Stops sending commands to the faulted LUN.
  - Flushes in-transit commands.
    - Procedure is protocol-specific.
  - Marks flushed commands for resend.
  - Next command sent with ACA attribute
  - Sends CLEAR EXCEPTION request
- Resends marked commands when requestedby application client.

SCSI-2 Compatibility

- What the Application client sees:
  - Behavior is identical to parallel SCSI.
  - Command Queue frozen as for CAM.
    - No out-of-order command execution.
  - Contingent Allegiance
    - Sense data automatically preserved.
  - Application Client interface for manipulating the queue of unsent SCSI commands
    - Implementation-specific but protocol independent.
- What the application client doesn't see:
  - CLEAR EXCEPTION sent by initiator's Protocol layer
  - Management of 'pending command list' by protocol layer.

Auto Contingent Allegiance Recovery



- The initiator's protocol layer, on receiving the exceptionstatus:
  - Passes the exception status to the application client.
  - Stops sending commands to the faulted LUN.
  - <u>Does not</u> flush in-transit commands.
  - Passes all EXCEPTION ACTIVE statuses to application clients.
- No marked commands to resend.
- Application client sends one or more ACA commands followed byCLEAR ACA request.
- ACA commands do not automatically clear the exception.