SCSI EH and the real world

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Introduction

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- Including an error recovery strategy
- Has been in the linux kernel since time immemorial
- And what with it being heavily used, it will have been tested thoroughly by now.

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  … And then real life kicked in

An angry customer

- Received a customer call:

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  … Good question. So what happened here?

SCSI Error Handling

SCSI Error handling in general

- SCSI is governed by T-10 standards
- Everything regarding SCSI commands and SCSI command handling is specified:
  - SCSI command specifications (SPC, SBC, etc)
  - SCSI command transport (SAS, FC, iSCSI etc)
  - SCSI architecture model (SAM)

SCSI error recovery

- Some hints can be glanced from the SCSI architectural model
- Defines *Task Management Functions* to control commands and command sets:
  - Task abort
  - Task set abort
  - LUN Reset
- But error recovery itself is not specified

SCSI error recovery implementations

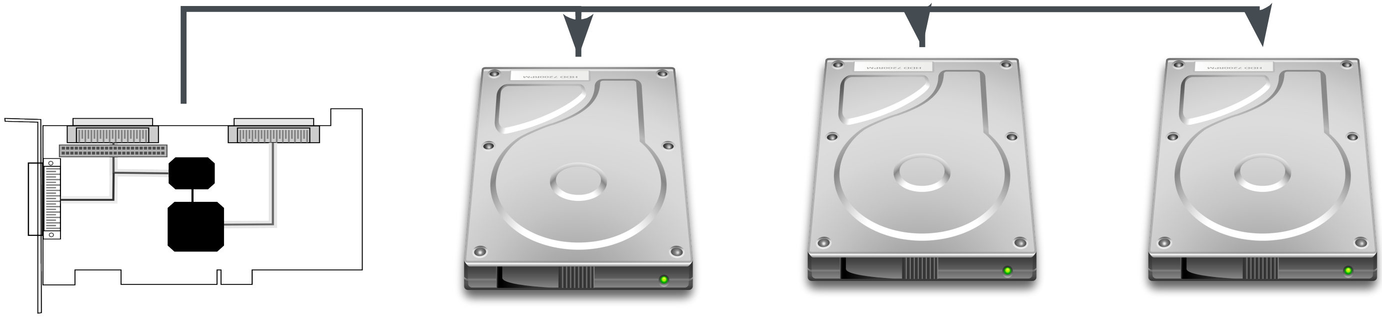
- No specification, so devise your own
- Implementation based on architecture details, with tweaks accumulating over time

SCSI-EH on Linux

Linux SCSI EH

- Originally implemented in Linux 2.2, based on the then-up-to-date SCSI parallel HBAs
- Improvement over the prior, simple, error recovery procedures
- Modelled around the principles of parallel SCSI:
  - Bus topology
  - Bus is being driven by the HBA
  - Transaction between a single initiator and single targets only
  - Bus is capable of handling a single transaction at a time

SCSI Parallel bus topology



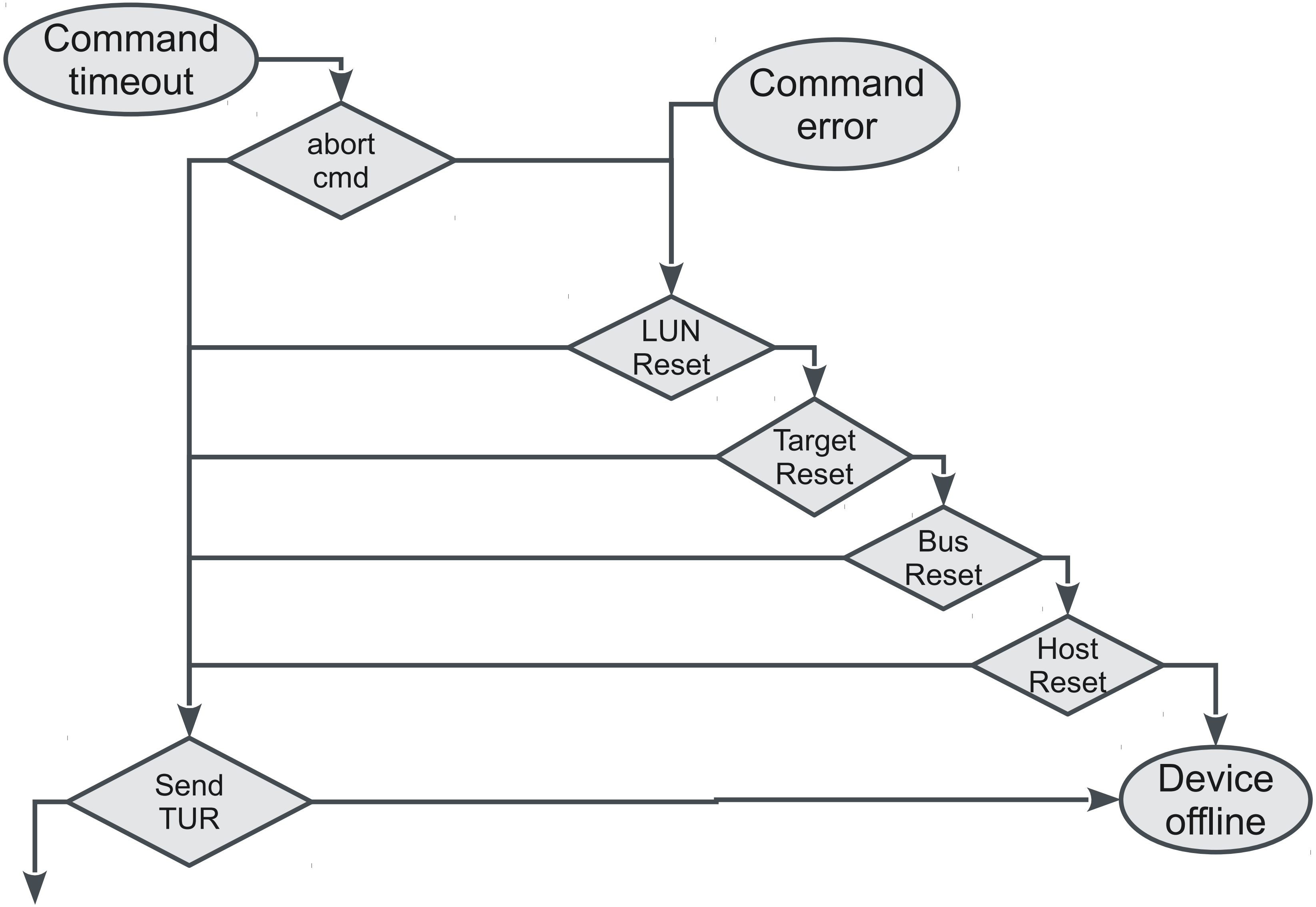
EH Principles

- Retry the command
- Quiesce bus prior to start EH
- Invoke EH strategy for each device referred to by a failed command
- Escalate to higher EH levels on failure
- Verify device operation after successful completion of EH strategy routine

EH Recovery Strategy

- Command abort
- Send Test Unit Ready
- LUN Reset
- Target Reset
- Bus Reset
- HBA Reset
- Offline device

EH recovery strategy



EH Recovery workflow

- Each failed command will be added to a list of failed commands
- Process this list after quiesce has been reached
- Each failed command is subjected to the error escalation strategy
- A command is considered ***recovered*** once an error recovery routine succeeds

EH Recovery cleanup

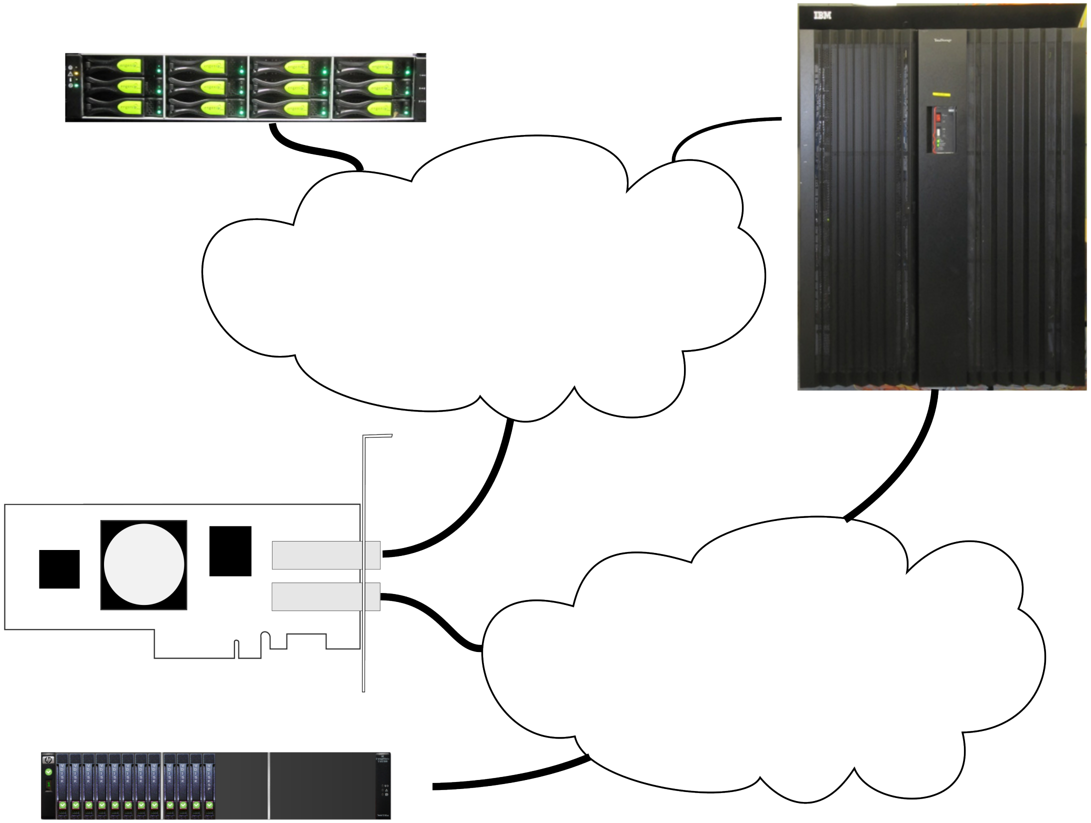
- A successful recovery is not identical with a working device:
  - A successful LUN RESET just means we've been able to send a LUN RESET command, NOT that the device actually has been reset
  - Nor does it means that the reset was able to fix the original issue
- Verify the recovery
- Send TEST UNIT READY command to verify the device is working

SCSI EH on FibreChannel

FibreChannel topology

- On FibreChannel (FC) the bus is no longer controlled by the HBA
- HBA participates on a shared network, which has an independent lifetime than the HBA
- SCSI devices (remote FC ports) are independent on the HBA
- Connection between the HBA and the remote ports might drop at any time (I_T nexus loss)

FC topology



FC and multipathing

- Multipath has been implemented to avoid temporary I/O failure
- Connect a single device via several paths to provide enhanced reliability
- Any I_T Nexus loss would translate into an I/O error, invoking SCSI EH
- SCSI EH would stop I/O etc.
- Multipath would stop until SCSI EH is finished

I_T nexus loss and SCSI EH

- Lower EH escalation steps require working communication with the device
- For an I_T Nexus loss this communication doesn't work, causing EH failure for those steps
- SCSI EH would cause a host reset, and offline the device after that
- Path cannot be recovered.

fc_block_scsi_eh() and dev_loss_tmo

- fc_block_scsi_eh(): Avoid any I_T Nexus Loss induced error by checking the connection state prior to call any EH recovery routine, waiting for the connection state to stabilize
- FAST_IO_FAIL: Add a flag to the request to avoid any retry in case of I_T Nexus loss failure.
- dev_loss_tmo: Add a timer tracking I_T Nexus loss; once the timer expires the remote port is assumed to be gone and will be deleted from the system

'Improved' EH for FibreChannel

- FAST_IO_FAIL flag suppresses command retries
- Distinct error code 'DID_TRANSPORT_DISRUPTED' to be returned in case of I_T Nexus loss
- Short-circuit SCSI EH by prefixing each EH routine with fc_block_scsi_eh()

  → Side-step EH for FibreChannel

SCSI EH on libata

Libata implementation

- Re-implement S-ATA support on top of SCSI
- Successor of the older IDE stack
- S-ATA error handling very rudimentary: commands either succeed or run into a timeout.
- Standard SCSI EH doesn't work, as the EH recovery routines have no equivalent on S-ATA
- Implement different EH routine via .eh_strategy_handler

SCSI EH on SAS

SAS and SCSI EH

- Working well with stock SCSI EH

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- Until someone connected a S-ATA CD-ROM

SAS and SCSI EH

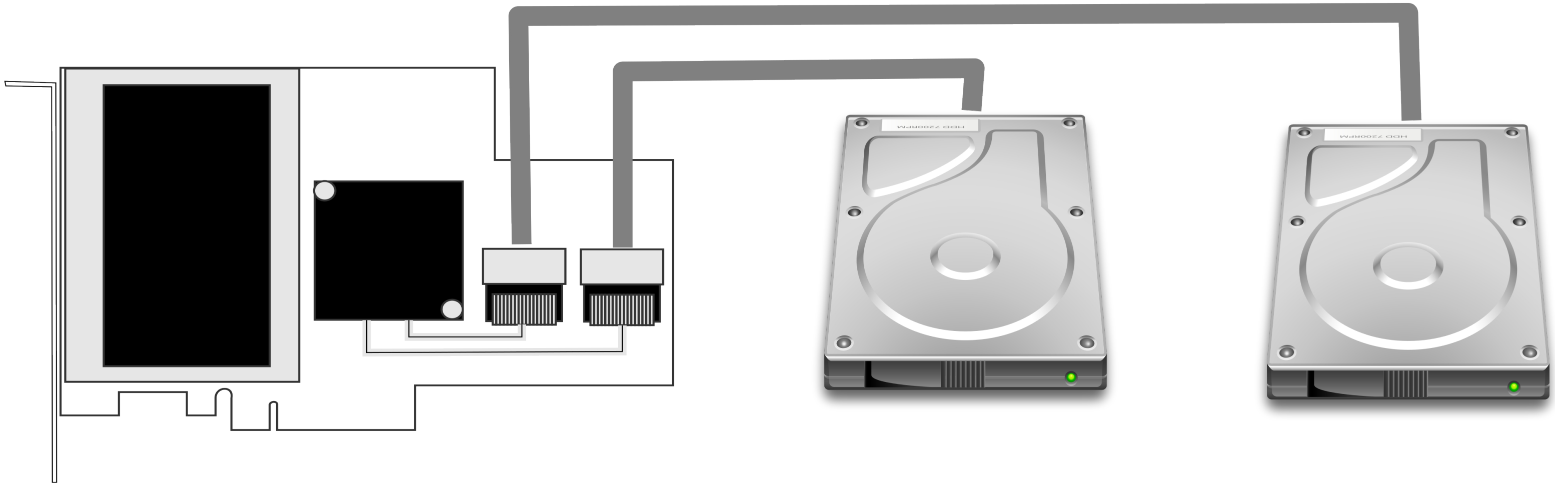
- Working well with stock SCSI EH
- Until someone connected a S-ATA CD-ROM
- Suddenly the entire system stalled every 5 seconds

  … WTF?

Libata oddities

- Libata has a 1:1 topology: one SCSI device maps to one SCSI host.
- The libata error recovery stops the SCSI host, figures out what's wrong with sending various commands, retrains the link etc until the device respond again.
- Sadly, a CD-ROM with empty slot will cause an ATA error as there's no medium present.
- And the linux kernel implement CD-ROM polling within the kernel.

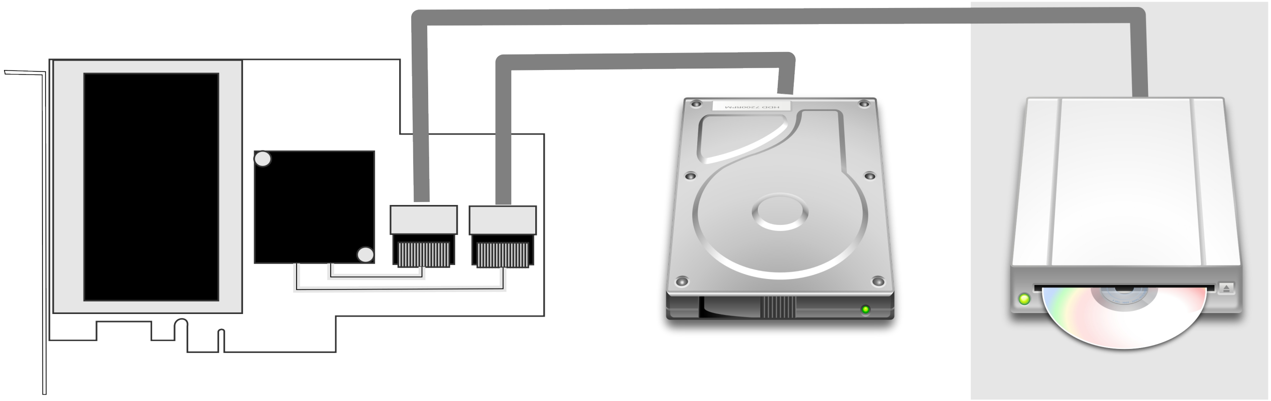
SAS topology



SAS and libata

- SAS HBAs offload S-ATA devices to libata stack
- S-ATA devices show up alongside normal SAS devices as a 'normal' LUN.
- Each SAS HBA will be represented by a single SCSI host

Mixed SAS/S-ATA topology



libsas

libata

CD-ROM polling on SAS/libata

- Kernel polls CD-ROM

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- All I/O to LUNs connected to that Host is stopped.

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- SCSI Host is stopped.
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Oops …

SAS EH modification

- Not use standard SCSI EH routines
- Implement separate .eh_strategy_handler for SAS

So where do we stand now?

Analysis of the customer problem

- Switch firmware issues caused the HBA to not detect a remote port failure
- HBA continues to send I/O to the removed rport
- *(wait 5 x 30 seconds)*
- First I/O times out
- SCSI EH starts, waiting for all outstanding commands
- (*wait for another 5 x 30 seconds)*
- SCSI EH recovery starts after the last command timed out

Analysis of the customer problem

- EH recovery, first level: command abort
  - send command abort for the first command
  - *(wait for timeout)*
  - Abort the command abort
  - (continue for all commands)
- Escalate to next level: LUN reset

Analysis of the customer problem

- EH recovery, second level: LUN reset
  - send LUN Reset for the first device
  - *(wait for timeout)*
  - (continue for all devices)
- Escalate to next level: Target reset

Analysis of the customer problem

- EH recovery, third level: Target reset
  - send Target Reset for the first device
  - *(wait for timeout)*
  - (continue for all targets)
- Escalate to next level: Bus reset
- → Target Reset is deprecated with SPC-3

Analysis of the customer problem

- EH recovery, third level: Bus reset
  - FC does not have the concept of a 'bus', so most HBAs emulate 'Bus reset' by sending 'Target Reset' to all attached rports
  - *(wait for timeout)*
  - (continue for all targets)
- Escalate to next level: Host reset

Analysis of the customer problem

- EH recovery, forth level: Host reset
  - Issue Host reset
  - Host reset re-scans the attached remote ports
  - Remote port status in sync again
- EH recovery success
- Send TEST UNIT READY to all devices
- EH finished

SCSI EH Redesign

Current SCSI EH usage

- FC: Side-step SCSI EH
- Libata: separate EH handler
- SAS: separate EH handler
- Only parallel SCSI and iSCSI are still using stock SCSI EH
- Maybe we should be updating SCSI EH to make it more useful …

SCSI EH Redesign

- Overall goals:
  - Inline command aborts
  - Limit overall SCSI EH runtime
  - Release commands as early as possible
  - Reduce cross-speak during higher EH levels
  - Check for I_T Nexus loss

Inline command aborts

- Command timeouts can occur on FC with faulty SFPs
- Command abort has no dependency on other commands, just the originating command
- Send command abort once the timeout triggers, without waiting for EH to start
- Patchset posted to linux-scsi
- Reduce SCSI EH turn-around time by half (!)

Limit overall EH runtime

- Currently EH runtime is unbounded
- Hard to define system timeout, eg in cluster environment
- Implement an 'eh_deadline' setting
- After eh_deadline is reached SCSI EH drops down to host reset
- Patchset posted to linux-scsi

Release commands early

- SCSI EH keeps failed command in a list
- Commands will be completed after EH is finished
- Multipath failover can only happen after the command has been completed
- After LUN Reset all commands are discarded
- But: LUN Reset might fail, leaving commands in an unclear state (terminated? Not terminated?)

Reduce cross-speak at higher levels

- LUN Reset will terminat all I/O on that LUN, regardless on the initiator
- Spurious command aborts in multipath or cluster scenario
- Split 'LUN Reset' in two different stages:
  - Use 'Task Set abort' to terminate outstanding I/O
  - Use 'LUN Reset' to actually reset the LUN
- Remove Target Reset, deprecated
- Do not implement 'bus reset' on FC

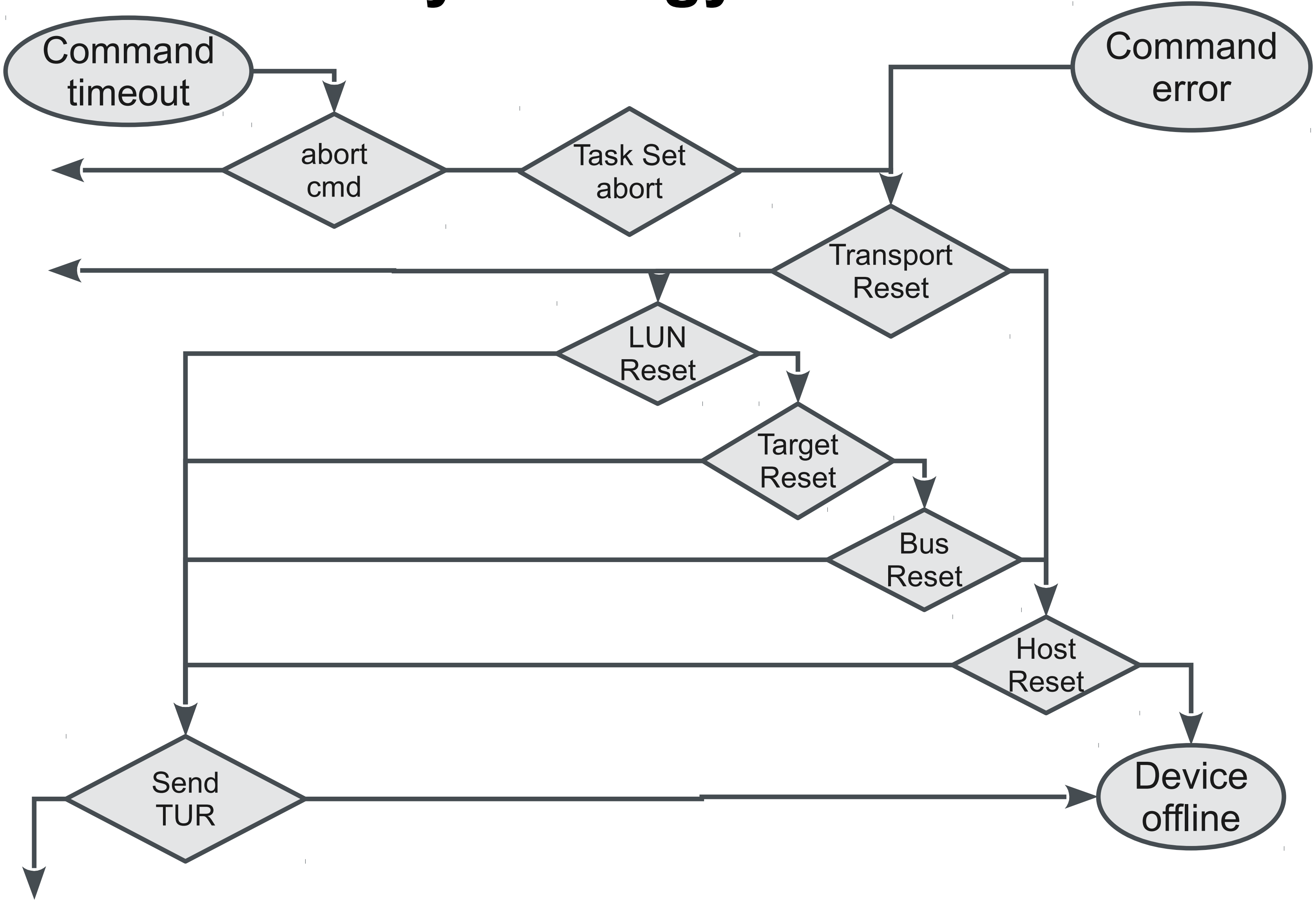
Check for I_T Nexus loss

- On FibreChannel SCSI EH cannot work during I_T Nexus Loss
- Current workaround is to wait in SCSI EH until dev_loss_tmo/fast_io_fail_tmo put the remote port into a definite state
- Implement an I_T Nexus reset EH step which is responsible for resetting the remote port

Proposed SCSI EH strategy

- Send command aborts after timeout
- EH Recovery starts:
  - Block I/O to the device
    - Issue 'Task Set Abort'
  - Block I/O to the target
    - Issue I_T Nexus Reset
    - Complete outstanding command on success
  - Engage current EH strategy
    - LUN Reset, Target Reset etc

EH recovery strategy



SCSI EH discussion points

Early command completion

- Complete commands after 'Abort Task Set'
- Unclear status if 'Abort Task Set' failed
- Easy way:
  - Require LLDDs to not refer to outstanding commands after 'Abort Task Set'
  - But then 'Abort Task Set' cannot really fail, as this is the precise meaning of that function
- Complicated way:
  - Keep the list of commands until one recovery step succeeds
- Best way still to be discussed

Check recovery level status

- Each recovery level can succeed or fail
- 'Success' currently only means that the recovery step has executed
- It does not mean that the recovery step did anything to correct the situation
- Separate verification required
- Action depends on the recovery level

Most recent sources are available at

```
git://github.com/hreinecke/scsi-devel
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