Additional Feet for the Penguin – SCSI over FCP Multipathing for Linux on System z

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Abstract

Using storage attachments with less than two independent paths is more than grossly negligent. So the solution is a waterproof multipathing setup. But that sounds easier than it is and there are several configuration pitfalls. This presentation will give you a multipathing overview and lights the multipathing configuration for SCSI devices connected over FCP.
Agenda

- Why multipathing?
- Multipathing for disk storage
- Root filesystem on multipathing device
- Multipathing for IBM tape drives
Why multipathing?

- High availability
  - Access during storage system maintenance
  - Usually required by enterprise disk systems
- Higher performance through load balancing
  - spread I/O load across multiple paths
  - ... across multiple FCP adapters
  - some storage systems use a preferred path
- Failover and Failback
  - hardware maintenance
  - microcode upgrades
  - storage system internal resets
Multipathing for disk storage

- spread load across channels
- keep I/O running during
  - channel recovery
  - configuration changes
- failover and failback
  - during storage maintenance
  - during channel maintenance
  - microcode updates
  - storage internal resets
Mulipathing for disk storage

- redundant controllers in DS8000
  - each controller can be offline for maintenance
- redundant SAN fabrics
  - availability during maintenance

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redundant FCP channels

redundant SAN fabrics

redundant storage controllers
Multipathing for disk storage in Linux

- device-mapper in Linux kernel and multipath-tools
- standard in distributions: RHEL, SLES, ...
- multipathing layer above block devices
- A SCSI device in Linux is now a path!
- Cross-platform: Linux on System z, p, x, ...
- Cross-vendor
- Used throughout storage test and device qualification tests
- supports more than two paths, the following example only uses two
multipathing components

- device-mapper: kernel infrastructure
- multipathd
  - reads configuration
  - establishes setup
  - queries storage
  - checks paths periodically: failback
- command line interface
  - multipath
  - multipathd
- kpartx: helper for partitions on multipath devices
- setup already includes sane default settings
I/O Stack for SCSI on Linux on System z

- Filesystem
- Block Devices / Device Mapper / LVM
- Linux SCSI layer
  - zfcp
  - Linux qdio module
  - z/VM
- FCP adapter

SAN

common Linux code, not System z specific
inside Linux system
(optional)
System z hardware
I/O Stack for SCSI on Linux on System z

Filesystem
Block Devices / Device Mapper / LVM
Linux SCSI layer
zfcp
Linux qdio module
z/VM
FCP adapter

Multipathing layer
inside Linux system
(optional)
System z hardware

SAN
multipathing example

- one disk
- two paths

1 LUN: 0x401040CC00000000

2 FCP Channels, device ids for Linux: 3c00 and 3d00

2 remote ports: 0x500507630313c562 0x500507630303c562
multipathing example

- attach ports and units for all paths
- path 1: 0.0.3c00 -> 0x500507630313c562 -> LUN
- path 2: 0.0.3d00 -> 0x500507630303c562 -> LUN
- recommendation: use zfcp config file from distribution
  - RHEL: /etc/zfcp.conf
  - SLES: /etc/sysconfig/hardware/hwcfg-zfcp-bus-ccw-0.0.*
multipathing example

- recommendation: use zfcp config file from distribution
- manual steps would be:

```
# cd /sys/bus/ccw/drivers/zfcp/
# echo 1 > 0.0.3c00/online
# echo 1 > 0.0.3d00/online
# echo 0x500507630313c562 > 0.0.3c00/port_add
# echo 0x500507630303c562 > 0.0.3d00/port_add
# echo 0x401040CC00000000 > 0.0.3c00/0x500507630313c562/unit_add
# echo 0x401040CC00000000 > 0.0.3d00/0x500507630303c562/unit_add
```
**multipathining example**

- zfcp and SCSI report each path as device

```bash
# lszfcp -D
0.0.3d00/0x50050763030bc562/0x401040cc00000000 0:0:0:1087127568
0.0.3c00/0x500507630313c562/0x401040cc00000000 1:0:0:1087127568

# lsscsi
[0:0:0:1087127568]disk IBM 2107900 2.27 /dev/sda
[1:0:0:1087127568]disk IBM 2107900 2.27 /dev/sdb
```
multipathing example

- 2 SCSI devices for the same disk volume:

  ```
  # scsi_id -g -s /block/sda
  36005076303ffc562000000000000010cc
  # scsi_id -g -s /block/sdb
  36005076303ffc562000000000000010cc
  ```

  Worldwide Identifier (WWID)
  Id for storage System + Id for disk volume

- queried from storage system
- multipathd uses this mechanism for mapping paths to disks
multipathing example

- Manually start multipathing (not recommended):

  ```
  # modprobe dm-multipath
  # multipathd
  
  # multipath -ll
  36005076303ff562000000000000010cc dm-0 IBM,2107900
  [size=5.0G][features=0][hwhandler=0]
  \_ round-robin 0 [prio=2][active]
  \_ 1:0:0:1087127568 sdb 8:16 [active][ready]
  \_ 0:0:0:1087127568 sda 8:0 [active][ready]
  ```
multipathing setup for SLES10

- add all paths to system
  - YaST or edit /etc/sysconfig/hardware/hwcfg-zfcp-*
  - hwup zfcp-bus-ccw-0.0.3c00

- enable device scanning and multipathd
  - chkconfig multipathd on
  - chkconfig boot.multipath on

- reboot or manually start multipath scripts
  - /etc/init.d/boot.multipath start
  - /etc/init.d/multipath start
multipathing setup for RHEL5

- attach all paths to system
  - /etc/zfcp.conf
  - /sbin/zfcpconf.sh or reboot
- Adjust provided /etc/multipath.conf
  
  ```
  #blacklist {
  #       devnode "*"
  #}
  
  #defaults {
  #       user_friendly_names yes
  #}
  ```

- chkconfig --add multipathd
- /etc/init.d/multipathd start
Checking multipathing status

```
# multipath -ll
36005076303ff56200000000000010cc dm-0 IBM, 2107900
[size=5.0G][features=0][hwhandler=0]
| round-robin 0 [prio=2][active]
| 1:0:0:1087127568 sdb 8:16 [active][ready]
| 0:0:0:1087127568 sda 8:0 [active][ready]
```

- Paths are combined automatically
- Each path is in one priority group
- multipathing device file `/dev/mapper/36005076303ff56200000000000010cc`
- Default settings are good, but can also be changed
Multipathing names and aliases

- user_friendly_names and aliases
  - /dev/mapper/mpath0 instead of /dev/mapper/36005076303fffc5620000000000010cc

- But: WWID is unique, alias maybe not
  - mapping depends on file /var/lib/multipath/bindings

- Recommendation: Use WWIDs

```
/dev/mapper/36005076303fffc562000000000000010*
```

WWIDs from storage system

But:

```
/dev/mapper/mpath0
/dev/mapper/mpath1
/dev/mapper/mpath2
```

depends on local mapping file
Multipathing with preferred path

- active / passive controller (DS6000)
- standard storage devices in default hardware table
- 2 pathgroups
  - active/enabled
  - automatically queried from storage (ALUA)

```
# multipath -ll
3600507630efffca200000000000001229 dm-0 IBM,1750500
[size=3.0G][features=1 queue_if_no_path]
[hwhandler=0]
  \_ round-robin 0 [prio=50][active]
  \_ 0:0:0:1076445202 sdaw 67:0   [active][ready]
  \_ round-robin 0 [prio=10][enabled]
  \_ 1:0:0:1076445202 sdcb 68:240 [active][ready]
```
 Hardware table

- combination of
  - default settings
  - redefined settings in /etc/multipath.conf

```bash
# multipath -t
...
devices {
...
  device {
    vendor "IBM"
    product "1750500"
    path_grouping_policy "group_by_prio"
    path_checker "tur"
    features "1 queue_if_no_path"
    prio "alua"
    failback "immediate"
  }
...
```
blacklist

- add and change in /etc/multipath.conf

```bash
# multipath -t
...
blacklist {
  devnode  ^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*
  devnode  ^hd[a-z]
  devnode  ^dcssblk[0-9]*
  device {
    vendor  DGC
    product LUNZ
  }
  device {
    vendor  IBM
    product  S/390.*
  }
}
blacklist_exceptions {
}
...
```
queue_if_no_path

- set as default
- queues I/O in memory in case all paths are down
- hides path failures from next layer
- disable for software mirror

![Diagram showing mirror setup and queue_if_no_path setting](image-url)
LVM2 and md on multipathing

- consider queue_if_no_path setting
- mirror and LVM on multipath devices, not SCSI device files!
- setup in /etc/lvm/lvm.conf
  - filter = [ "r|/dev/sd*"]

•
### multipathd: more status information

```bash
# multipathd -k
multipathd> show paths
hcil  dev dev_t pri dm_st  chk_st next_check
1:0:0:1087127568 sdb 8:16  1  [active][ready] XXXXXXX... 15/20
0:0:0:1087127568 sda 8:0   1  [active][ready] XXXXXXX... 15/20

multipathd> show multipaths status
name       failback queueing paths dm-st
36005076303ffc562000000000000010cc - off   2 active

multipathd> show multipaths stats
name       path_faults switch_grp map_loads
total_q_time q_timeouts
36005076303ffc562000000000000010cc 0 0 1 0
0 0

multipathd> help
...
```
Root file system on multipathing device

- example assumed root filesystem on dasd
- root file system on SCSI possible with SCSI IPL
- reliability requirements demand multipathing
- the same applies to swap partition
- Issues:
  - no support for multipathing in distro installers
  - start multipathing before mounting root filesystem
  - zipl does not write IPL record on multipath device file
zipl for multipath device

- add boot entry for single path
  - update procedure
    - boot to single path
    - update
    - zipl
    - boot to multipath
  - reliability during maintenance?

- or use additional disk volume for /boot
  - / on multipath
  - /boot on single path disk volume
  - write zipl IPL record on /boot disk volume
  - IPL /boot disk volume
  - uses additional disk volume

- recommendation: use additional disk volume for reliability
Installing root filesystem on multipath

- Install on single path.
- additional small disk for /boot
- Change to multipath setup after first boot
  - setup second path
  - use multipath device for root filesystem
  - recreate initrd with multipathing
  - zipl for changed initrd
root filesystem on multipath device

- final setup after reboot

```
# multipath -ll
36005076303ffc56200000000000010cc dm-0 IBM,2107900
[size=5.0G][features=1_queue_if_no_path][hwhandler=0]
  \_ round-robin 0 [prio=2][active]
  \_ 1:0:0:1087127568 sdc 8:32  [active][ready]
  \_ 0:0:0:1087127568 sda 8:0  [active][ready]

# mount
/dev/mapper/36005076303ffc56200000000000000010cc-part1 on /
type ext3 (rw,acl,user_xattr)
/dev/sdb1 on /boot type ext3 (rw,acl,user_xattr)
```
Tape drives and FCP

```
/dev/IBMtape0
  lin_tape / IBMtape
  Linux SCSI layer
  zfcp
  Linux qdio module

/dev/st0
  st
  Linux SCSI layer
  zfcp
  Linux qdio module

z/VM
FCP adapter

SAN
IBM tape drive
other tape drive
```
## Multipathing for IBM tape drives

### /dev/IBMtape0

<table>
<thead>
<tr>
<th>path failover</th>
<th>lin_tape / IBMtape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linux SCSI layer</td>
<td>zfcp</td>
</tr>
<tr>
<td></td>
<td>Linux qdio module</td>
</tr>
<tr>
<td>FCP adapter 1</td>
<td>FCP adapter 2</td>
</tr>
</tbody>
</table>

**SAN 1** | **SAN 2**

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**FCP adapter 1**

**FCP adapter 2**
Multipathing for IBM tape drives

- multipath-tools only cover disk storage
- lin_tape device driver provides multipathing for IBM tape drives
  - (IBMtape is the previous name for the same device driver)
- supported together with tape hardware
- does not cover data mirroring or drive failover, handled by
  - backup application
  - media management application
- lin_tape setup in /etc/modprobe.conf.local
  - options lin_tape alternate_pathing=1
Summary

- multipathing is required for reliability
- multipath-tools are the standard solution for disks
- go with default settings, only do minimal changes
- SCSI device files are paths in multipathing
- basic setup is simple
- root filesystem on multipath device requires more effort
- multipathing for IBM tape drives available
Resources

- Device-mapper Resource Page (link to Multipath bug tracking)
  http://sources.redhat.com/dm/

- Device-mapper and LVM2 Wiki
  http://sources.redhat.com/lvm2/wiki/MultipathUsageGuide

- multipath tools FAQ
  http://git.kernel.org/?p=linux/storage/multipath-tools/.git;a= blob;f=FAQ

- How to setup / use multipathing on SLES

- Enabling root-on-multipath for SLES9 on zSeries
  http://linuxvm.org/Info/HOWTOs/root-on-multipath.html

- Redhat: Using Device-Mapper Multipath

- IBMtape/lin_tape driver and documentation

- multipath-tools
  http://christophe.varoqui.free.fr/
Thank You!

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