SCSI over Fibre Channel Support for Linux on zSeries

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Agenda

- zSeries Hardware
  - Hardware Requirements
  - zSeries in a FC SAN
  - Topologies
- zSeries Software
  - Software Requirements
  - Linux SCSI/FCP Support
  - Multi-Pathing
- Storage Devices
  - Disk, Tape
- SCSI IPL
zSeries in a SAN – Sharing Storage Resources
zSeries in a SAN – Sharing Storage Resources

ESCON

FICON

Tape Disk

Tape Disk

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zSeries in a SAN – Sharing Storage Resources

Tape  Disk

ESCON

Tape  Disk

FICON

Fibre Channel SAN

Tape  Disk

FCP

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ESCON

FICON

Fibre Channel SAN

FCP

Tape Disk

Tape Disk CD DVD
zSeries in a SAN – Hardware Requirements

- IBM zSeries 800, 890, 900 or 990
- FICON or FICON Express adapter card
- Additional CHPID type FCP
- FC fabric switch
- FC attached storage devices
- Optional: FCP-SCSI bridge
  + SCSI devices
zSeries in a SAN – Topologies

- Point-to-point: not supported
- Direct attached arbitrated loop: not supported
- Switched fabric: supported
FC and SCSI – Software Requirements

- **SUSE Linux Enterprise Server 8 (SLES8)**
  - GA November 2002
  - Currently SP3 (submarine)

- **SUSE Linux Enterprise Server 9 (SLES9)**
  - GA August 2004

- **Red Hat Enterprise Linux 3 (RHEL3)**
  - GA October 2003
  - Update 3

- **z/VM 4.3**
  - GA May 2002
  - Includes FCP channel guest support for Linux
  - Currently z/VM 5.1
Linux SCSI Stack

- VFS / File System
- Buffer Cache
- Multipathing (LVM, EVMS, MD)
- SCSI Disk
- Uniform CD-ROM
- SCSI CD-ROM
- SCSI Mid Layer
- SCSI Tape
- SCSI Generic
- HBA Driver A
- HBA Driver B
- zlib
- zfcp
- Linux SCSI Stack
zfcp's Task in the Linux SCSI Stack

- zfcp drives the zSeries FCP host bus adapter.
  - maintains connections through the SAN to SCSI devices attached via a zSeries FCP adapter.
  - maps SAN devices to SCSI devices as seen by the Linux SCSI subsystem.
  - sends SCSI commands and associated data on behalf of the Linux SCSI subsystem to SCSI devices attached via a zSeries FCP adapter.
  - returns replies and data from SCSI devices to the Linux SCSI subsystem.
SAN Addressing

- **Device Number** (devno)
  - e.g. 0x6000

- **Worldwide Port Name** (WWPN)
  - e.g. 0x5005076300ce93a7

- **Logical Unit Number** (LUN)
  - e.g. 0x1234000000000000
SysFS

- New file system with Linux kernel 2.6
- Contains all device drivers and device specific information
- It is NOT a substitution of the /proc file system
- Used to configure device drivers

```
/sys
    /block
        /ccw
            /ccwgroup
                /drivers
                    /devices
            /devices
        /iucv
            /drivers
                    /devices
        /devices
            /css0
                sub-tree for all devices connected to the channel subsystem
    /bus
        sub-tree for channel subsystem device drivers and devices
        sub-tree for group device drivers and devices
        sub-tree for IUCV device drivers and devices
```
Configuration – Set Adapter Online

```
[root: root]# cd /sys/bus/ccw/drivers/zfcp/
[root: zfcp]# ls
0.0.5588 loglevel_cio loglevel_config loglevel_erp
loglevel_fc loglevel_fsf loglevel_other
loglevel_qdio loglevel_scsi version
[root: zfcp]# cd 0.0.5588/
[root: 0.0.5588]# ls
availability card_version cmb_enable cutype detach_state
devtype failed fc_link_speed fc_service_class fc_topology
hardware_version in_recovery lic_version online port_add
port_remove s_id scsi_host_no serial_number status wwnn
wwpn
```

```
[root: 0.0.5588]# cat online
0
[root: 0.0.5588]# echo 1 > online
[root: 0.0.5588]# cat online
1
```
Configuration – Add a Port to the Adapter

[root: 0.0.5588]# ls
availability card_version cmb_enable
... port_add ... status wwpn
[root: 0.0.5588]# echo 0x5005076300c693cb > port_add
[root: 0.0.5588]# ls
0x5005076300c693cb availability card_version
cmb_enable cutype detach_state devtype failed
fc_link_speed fc_service_class fc_topology
hardware_version host0 in_recovery lic_version
nameserver online port_add port_remove s_id
scsi_host_no serial_number status wnn wwpn
[root: 0.0.5588]# cd 0x5005076300c693cb
[root: 0x5005076300c693cb]# ls
d_id detach_state failed in_recovery scsi_id
status unit_add unit_remove wnnn
Configuration – Add a Unit to the Port

[root: 0x5005076300c693cb]# ls
d_id detach_state failed in_recovery scsi_id
status unit_add unit_remove wwnn
[root: 0x5005076300c693cb]# echo 0x5125000000000000 > unit_add
[root: 0x5005076300c693cb]# ls
0x5125000000000000  d_id detach_state failed
in_recovery scsi_id status unit_add unit_remove
wwnn
[root: 0x5005076300c693cb]# cd 0x5125000000000000/
[root: 0x5125000000000000]# ls
detach_state failed in_recovery scsi_lun status

[root: 0x5125000000000000]# lsscsi
[0:0:1:0] disk IBM 2105F20 .693 /dev/sda
[root: 0x5125000000000000]#
Block Device View

```
[root: root]# cd /sys/block/
[root: block]# ls
dasda dasdb loop0 loop1 loop2 loop3 loop4 loop5
loop6 loop7 ram0 ram1 ram2 ram3 ram4 ram5 ram6 ram7
ram8 ram9 ram10 ram11 ram12 ram13 ram14 ram15 sda
[root: block]# cd sda
[root: sda]# ls
dev device queue range sda1 size stat

[root: sda]# cat dev
8:0
[root: sda]# cat range
16
[root: sda]# cat size
3906304
```
FCP – SCSI Mapping

**FCP World**

- **HBA**
- **WWPN**
- **FCP LUN**

**SCSI World**

- **Host**
- **Bus**
- **SCSI ID**
- **SCSI LUN**
SCSI View

[root: root]# cd /sys/bus/scsi/devices/
[root: devices]# ls
0:0:1:0
[root: devices]# cd 0:0:1:0
[root: 0:0:1:0]# ls
block delete detach_state device_blocked
fcp_lun generic hba_id model online
queue_depth rescan rev scsi_level type
vendor wwpn
FCP – SCSI Mapping

[root: root]# cd /sys/bus/ccw/drivers/zfcp/0.0.5588/
[root: 0.0.5588]# cat scsi_host_no
0x0
[root: 0.0.5588]# cd 0x5005076300c693cb
[root: 0x5005076300c693cb]# cat scsi_id
0x1
[root: 0x5005076300c693cb]# cd 0x5125000000000000
[root: 0x5125000000000000]# cat scsi_lun
0x0

[root: root]# cd /sys/bus/scsi/devices/0:0:1:0/
[root: 0:0:1:0]# cat hba_id
0.0.5588
[root: 0:0:1:0]# cat wwpn
0x5005076300c693cb
[root: 0:0:1:0]# cat fcp_lun
0x5125000000000000
Adapter Information

- <directory for each configured target port>
- Adapter serial number
- LIC version number
- SCSI host number
- Worldwide node name
- Worldwide port name
- fibre Channel topology
- Link Speed

```
# cd /sys/bus/ccw/drivers/zfcp/0.0.5588/
# cat serial_number
IBM0200000001AB8A
# cat lic_version
0x000000206
# cat scsi_host_no
0x0
# cat wwnn
0x5005076400c1ab8a
# cat wwpn
0x5005076401602fd8
# cat fc_topology
fabric
# cat fc_link_speed
2 Gb/s
```
Port Information

- `<directory for each FCP LUN>`
- `in_recovery` - Recovery status
- `scsi_id` - SCSI ID
- `failed` - Port error recovery status
- `d_id` - Destination ID
- `wwnn` - Worldwide node name

```
# cd /sys/bus/ccw/drivers/zfcp/0.0.5588/0x5005076300c693cb/
# ls
0x5125000000000000 d_id detach_state failed in_recovery
scsi_id status unit_add unit_remove wwnn
# cat in_recovery
0
# cat scsi_id
0x1
# cat d_id
0x632e13
```
Unit Information

- in_recovery - Recovery status
- scsi_lun - Linux SCSI LUN
- failed - Unit error recovery status
- status - Debug Info

# cd /sys/bus/ccw/drivers/zfcp/0.0.5911/0x5005076300cc0b8e/0x5108000000000000/
# ls
detach_state  failed  in_recovery  scsi_lun  status
# cat failed
0
# cat in_recovery
0
# cat scsi_lun
0x0
# cat status
0x60000000
FCP Multipathing

- SLES8
  - LVM – Logical Volume Manager

- SLES9
  - Device Mapper subsystem in 2.6 kernel
  - EVMS – Enterprise Volume Management System
  - LVM2 – Logical Volume Manager

- RHEL3
  - MD
  - mdadm – multiple device administration
FCP Multipathing

- Failover on path-failure
- Failback if recovered path is detected (retries)
- Load balancing (use of multiple paths for concurrent I/Os according to assigned priorities)
- Designed to cover all block devices
FCP Multipathing – Devices

Logical Devices

SCSI Block Devices

Physical Devices

X,1,A  X,2,A  Y,1,A  Y,2,A

X,B  Y,B
FCP Multipathing – LVM

- **Notations**
  - Physical volumes
  - Logical volumes
  - Volume groups
- `/etc/zfcp.conf`
- **Only one path enabled by default**
- `/proc/lvm/`

- **Standard LVM commands**
  - pvcreate
  - vgcreate
  - vgdisplay
  - lvcreate

- **Multipath LVM commands**
  - pvpath
  - pvpathsave
  - pvpathrestore
FCP Multipathing – EVMS

- Graphical EVMS management tool
- Segment, segment manager
- Region and MD multipath region manager
- MD Raid 0 Region manager
FCP Multipathing – MD

- No load balancing
- Primary – secondary path or actual path – spare path
- Attention: md subsystem is quite verbose

- FCP mapping in modules.conf on ramdisk (single line!)
- Create device nodes (mknod /dev/sda b 8 0)
- Configure mdadm (/etc/mdadm.conf)
- /etc/rc.d/rc.sysinit – enabling on Linux startup

```
mdadm -C /dev/md1 -level=multipath -raid-device=2 /dev/sda1 /dev/sdd1
mdadm -C /dev/md2 -level=multipath -raid-device=2 /dev/sdb1 /dev/sde1
mdadm -C /dev/md3 -level=multipath -raid-device=2 /dev/sdc1 /dev/sdf1
mdadm -C /dev/md0 -level=raid0 -raid-devices=3 /dev/md1 /dev/md2 /dev/md3
```
## Disk Usage – ECKD and SCSI Comparison

<table>
<thead>
<tr>
<th></th>
<th>ECKD DASD</th>
<th>SCSI Disk</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Configuration</strong></td>
<td>IOCDS/VM (Operator)</td>
<td>IOCDS/VM &amp; Linux (Operator &amp; Linux Admin)</td>
</tr>
<tr>
<td><strong>Access Method</strong></td>
<td>SSCH</td>
<td>QDIO</td>
</tr>
<tr>
<td><strong>Block Size (Byte)</strong></td>
<td>512, 1K, 2K, 4K</td>
<td>512</td>
</tr>
<tr>
<td><strong>Disk Size</strong></td>
<td>3390 Model 3/9/27 now variable too</td>
<td>any</td>
</tr>
<tr>
<td><strong>Formatting (low level)</strong></td>
<td>dasdfmt</td>
<td>not necessary</td>
</tr>
<tr>
<td><strong>Partitioning</strong></td>
<td>fdasd</td>
<td>fdisk</td>
</tr>
<tr>
<td><strong>File System</strong></td>
<td>mke2fs (or others)</td>
<td></td>
</tr>
<tr>
<td><strong>Access</strong></td>
<td>mount</td>
<td></td>
</tr>
</tbody>
</table>
FICON and FCP Performance

IBM Lab Boeblingen, 03/2003

<table>
<thead>
<tr>
<th>Maximum Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
</tr>
<tr>
<td>250</td>
</tr>
<tr>
<td>200</td>
</tr>
<tr>
<td>150</td>
</tr>
<tr>
<td>100</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>0</td>
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</tbody>
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<table>
<thead>
<tr>
<th>MB/sec</th>
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<tbody>
<tr>
<td>300</td>
</tr>
<tr>
<td>250</td>
</tr>
<tr>
<td>200</td>
</tr>
<tr>
<td>150</td>
</tr>
<tr>
<td>100</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

FICON / FCP comparison, LPAR, 31 bit

- ext2, single disk
- ext2, multiple disks
- ext3, single disk
- ext3, multiple disks

- FICON write
- FCP write
- FICON read
- FCP read
OLTP Workload Informix – I/O Options

Informix database server, disk I/O options

Transactions per minute

- ECKD
- SCSI
- z900, ext2
FCP/SCSI Tape Support

- **Tape Devices:**
  - IBM TotalStorage Enterprise Tape System 3590.
  - IBM TotalStorage Enterprise Tape Drive 3592.
  - IBM TotalStorage Enterprise Tape Library 3494.
  - IBM TotalStorage UltraScalable Tape Library 3582, 3583 and 3584 w/ Ultrium 2 Fibre Channel Tape Drives.

- IBMtape and IBMtapeutil packages required
  - `/lib/modules/(Your system’s kernel name)/kernel/drivers/scsi/IBMtape.o`
  - `/usr/bin/IBMtapeconfig`
  - `/usr/bin/IBMtaped`
  - `/usr/bin/IBMtapeutil`
FCP/SCSI Tape Support

- IBMtape special files (created by IBMtapeconfig):
  - /dev/IBMtape0
  - /dev/IBMtape0n
  - /dev/IBMchanger0

- Tape utility program (IBMtapeutil):

  # Mount cartridge from slot 3
  IBMtapeutil -f /dev/IBMchanger0 mount 3

  # Backup myfile.tar to tape
  IBMtapeutil -f /dev/IBMtape0 write -s myfile.tar
Device Support - Summary

- **Devices (via switch)**
  - IBM TotalStorage Enterprise Tape System 3590
  - IBM TotalStorage Enterprise Tape Drive 3592
  - IBM TotalStorage Enterprise Tape Library 3494
  - IBM TotalStorage Enterprise Storage Server Models 750, 800, F20, F10
  - IBM TotalStorage UltraScalable Tape Library 3582, 3583 and 3584 w/ Ultrium 2 Fibre Channel Tape Drives

- **Director/Switch Support**
  - CISCO MDS 9000 Family (IBM 2062)
  - CNT (INRANGE) FC/9000 64-port, 128-port and 256-port models (IBM 2042)
  - McDATA Intrepid 6064 (IBM 2032) and 6140 (IBM 2032)
  - McDATA 3232 (IBM 2031-232)
  - McDATA Sphereon 4500 Fabric Switch (IBM 2031-224)
  - IBM total Storage SAN Switch 2109-M12, 2109-F16 and S16/S08
  - IBM 2108-G07 SAN Data Gateway (parallel SCSI connectivity to non-IBM storage)
  - McDATA ES-1000 Loop Switch (IBM 2031-L00) FCP-to-FC-AL Bridge
  - McDATA ED-5000 (IBM 2032-001)
SCSI IPL & SCSI Dump

- SCSI IPL from FCP attached SCSI disks.
- SCSI Dump to FCP attached SCSI disks (LPAR only).

- Expand the world of open I/O attachments on zSeries from pure data access to allow IPL and Dump support.
- Enhances the setup to allow Linux on zSeries to run completely on SCSI disks - incl. IPL, Data access and Dump support.

- New set of IPL parameters.
- LPAR and z/VM guests supported.
SCSI IPL & SCSI Dump – Cont.

- Disk preparation with Linux „zipl“ tool
- Up to 31 boot configurations possible

Requirements:
- Requires enablement by FC9904
- Requires FCP channels
- IBM zSeries server 800, 890, 900 or 990
- z/VM 4.4 (PTF UM30989)
FCP/SCSI on Linux For zSeries - Summary

- FCP/SCSI support for IBM zSeries.
  - New FCP channel based on FICON / FICON Express cards.
  - FCP channel support in z/VM 4.3 and higher for Linux guests.
  - First FCP/SCSI exploitation for zSeries in SLES8 and RHEL3.
- Integration of your zSeries into standard based FC SANs.
- New device types.
- Reduced emulation overhead in OS and ESS compared to ECKD due to native use of fixed block I/O.
- Larger disks in comparison to ESCON/FICON.
- Current restrictions:
  - Only switched fabric supported.
  - No LUN sharing or zoning on a single adapter; use separate physical adapters.
Useful Links

- I/O Connectivity on IBM zSeries mainframe servers
- Getting Started with zSeries Fibre Channel Protocol, IBM Redpaper
- z/VM Version 4 Release 4
- SUSE Linux Enterprise Server 8
- Linux for zSeries and S/390
- Linux Device Drivers and Installation Commands
  - Kernel 2.4: http://oss.software.ibm.com/linux390/docu/lx24jun03dd02.pdf
  - Kernel 2.6: http://oss.software.ibm.com/linux390/docu/lx26apr04dd00.pdf
- IBM TotalStorage Tape Device Drivers – Installation and User’s Guide
- ESS Fibre Channel Attachment White Paper
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