SCSI over FCP for Linux on System z – Introduction and New Features

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2008-08-13
Session 9259
Abstract

The Linux zfcp device driver adds support for Fibre Channel attached SCSI devices to Linux on System z. The Fibre Channel protocol is an open, standard-based alternative and supplement to existing ESCON or FICON connections and becomes more and more important. The intention of this presentation is to give an introduction to the SCSI world on a System z mainframe. This presentation will cover hardware and software requirements, configuration, performance considerations, IPL and dump. Other points will be FCP support in recent Linux distributions and new features to improve the FCP support in Linux on System z.
Agenda

- Introduction
- Channel I/O vs. SCSI
- Hardware requirements
- Software, Configuration
- SCSI IPL
- SCSI dump
- Linux distribution support
- NPIV
- New features
Introduction

- connect System z to Open Systems storage (disk, tape, ...)
- integrate in existing Storage Area Networks (SANs)
- resource sharing with Open Systems
- I/O uses SCSI over Fibre Channel Protocol (FCP)
- System z FICON Express card
- zfcp as device driver in Linux
SAN topologies and System z

- point-to-point
- direct attached arbitrated loop
- switched fabric

not supported

Disk  Tape

Disk  Tape

Disk  Tape
FCP channel and subchannel

Linux connects through FCP subchannels to FCP attached storage.

A subchannel is identified – in Linux - by its bus identifier which is derived from the subchannel's device number.

sample FCP subchannel (as seen in Linux):
/sys/bus/ccw/drivers/zfcp/0.0.50d4
World Wide Port Names (WWPNs)

Storage devices and servers attach through Fibre Channel ports (called N_Ports).

An N_Port is identified by its World-Wide Port Name (WWPN).

For redundancy, servers or storage may attach through several N_Ports.

sample WWPN: 0x5005076300c20b8e
Logical Unit Numbers (LUNs)

Storage devices usually comprise many logical units (volumes, tape drives, ...).

A logical unit is identified by its Fibre Channel Protocol Logical Unit Number (FCP LUN).

Sample FCP LUN: 0x4010400200000000
Accessing SAN storage

- **FCP device id**
  - e.g. 0.0.e962

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

- **Logical Unit Number (LUN)**
  - e.g. 0x4012403400000000
SCSI compared to Channel I/O

- FCP adapter is defined in System z I/O configuration
- Ports and LUNs attachment handled in Operating Systems
- Multipathing handled in Operating System
- No disk size restrictions for SCSI disks
- Additional configuration outside System z necessary
  - Zoning in the SAN fabric
  - LUN masking on the storage server
Hardware requirements

- IBM zSeries 800, 890, 900 or 990
- IBM System z9 or z10
- FICON or FICON Express adapter cards
- Fibre Channel storage system
- Optional:
  - Fibre Channel switch (for Fabric topology)
  - IBM System z9 or z10 (for NPIV support)
Hardware: Define FCP adapter in IOCDF

CHPID PATH=(CSS(0,1,2,3),51),SHARED, *
   NOTPART=((CSS(1),(TRX1), (=)),(CSS(3),(TRX2,T29CFA), (=))) *
   PCHID=1C3,TYPE=FCP
CNTLUNIT CUNUMBR=3D00, *
   PATH=((CSS(0),51),(CSS(1),51),(CSS(2),51),(CSS(3),51)), *
   UNIT=FCP
IODEVICE ADDRESS=(3D00,001),CUNUMBR=(3D00),UNIT=FCP
IODEVICE ADDRESS=(3D01,007),CUNUMBR=(3D00), *
   PARTITION=((CSS(0),T29LP11,T29LP12,T29LP13,T29LP14,T29LP* 
   15),(CSS(1),T29LP26,T29LP27,T29LP29,T29LP30),(CSS(2),T29* 
   LP41,T29LP42,T29LP43,T29LP44,T29LP45),(CSS(3),T29LP56,T2* 
   9LP57,T29LP58,T29LP59,T29LP60)),UNIT=FCP
IODEVICE ADDRESS=(3D08,056),CUNUMBR=(3D00), *
   PARTITION=((CSS(0),T29LP15),(CSS(1),T29LP30),(CSS(2),T29* 
   LP45),(CSS(3),T29LP60)),UNIT=FCP
Software requirements

- zfcp is part of standard Linux kernel and standard distributions
- supported Linux distributions
  - SLES9
  - SLES10
  - RHEL4
  - RHEL5
- Recommendations
  - start with latest available update / service pack
  - include Linux in maintenance planning
  - check for possibly related z/VM PTFs
I/O stack for SCSI and Linux

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

common Linux code
inside Linux system
(optional)
System z hardware
Command line setup (SLES9/10, RHEL4/5)

```bash
# cd /sys/bus/ccw/drivers/zfcp/0.0.3c00/
# echo 1 > online
# echo 0x500507630313c562 > port_add
# echo 0x401040cc00000000 > 0x500507630313c562/unit_add

# lszfcp -D
0.0.3c00/0x500507630313c562/0x401040cc00000000
0:0:0:1087127568

# lsscsi -t
[0:0:0:1087127568]disk fc:0x500507630313c562,0x650d13 /dev/sda
```
Persistent setup: SLES

- through YaST or
- setup in /etc/sysconfig/hardware/hwcfg-zfcp-bus-ccw-0.0.*
Persistent setup: RHEL

- Installer GUI or
- `/etc/zfcp.conf`
- SCSI and SCSI LUN are unused fields (use 0, 1, ...)

![Red Hat Enterprise Linux AS Installer](image)
Multipathing considerations

- storage controllers allow different paths
- path failover required for
  - storage system maintenance
  - SAN fabric maintenance (with dual fabrics)
- implemented inside Linux
- disk storage: multipath-tools
- IBM tape drives: lin_tape driver
- more details: Session 9289, “Additional Feet for the Penguin - SCSI over FCP Multipathing for Linux on System z”
SCSI IPL

- Similar to IPL from DASD
- Requires to address the SCSI disk
  - FCP adapter id
  - Remote port
  - LUN
SCSI IPL example with z/VM

00:
00: CP SET LOADDEV PORTNAME 50050763 0313C562 LUN 401040CF 00000000
00:

00: CP Q LOADDEV
PORTNAME 50050763 0313C562 LUN 401040CF 00000000 BOOTPROG 0
BR_LBA 00000000 00000000
00:

00: CP IPL 3C00
00: HCPLDI2816I Acquiring the machine loader from the processor controller.
00: HCPLDI2817I Load completed from the processor controller.
00: HCPLDI2817I Now starting the machine loader.
01: HCPGSP2630I The virtual machine is placed in CP mode due to a SIGP stop and store status from CPU 00.
00: MLOEVL012I: Machine loader up and running (version 0.18).
00: MLOPDM003I: Machine loader finished, moving data to final storage location.
Linux version 2.6.16.60-0.9-default (geeko@buildhost) (gcc version 4.1.2 20070115 (SUSE Linux)) #1 SMP Mon Mar 17 17:16:31 UTC 2008
We are running under VM (64 bit mode)
Detected 2 CPU's
Boot cpu address 0
Built 1 zonelists
Kernel command line: root=/dev/disk/by-id/scsi-36005076303fffc562000000000000010ce-part1 TERM=dumb
### SCSI IPL for LPARs

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPC</td>
<td>H05:H05LP26</td>
</tr>
<tr>
<td>Image</td>
<td>H05:H05LP26</td>
</tr>
<tr>
<td>Load type</td>
<td>○ Normal ○ Clear ○ SCSI ○ SCSI dump</td>
</tr>
<tr>
<td>Store status</td>
<td></td>
</tr>
<tr>
<td>Load address</td>
<td></td>
</tr>
<tr>
<td>Load parameter</td>
<td></td>
</tr>
<tr>
<td>Time-out value</td>
<td>60 to 600 seconds</td>
</tr>
<tr>
<td>Worldwide port name</td>
<td>50050763030BC56;</td>
</tr>
<tr>
<td>Logical unit number</td>
<td>4011400B00000000C</td>
</tr>
<tr>
<td>Boot program selector</td>
<td></td>
</tr>
<tr>
<td>Boot record logical block address</td>
<td></td>
</tr>
<tr>
<td>Operating system specific load parameters</td>
<td></td>
</tr>
</tbody>
</table>

**Buttons:** OK Reset Cancel Help
**SCSI dump**

- Dump memory of one LPAR to disk for problem analysis
- Similar to VMDUMP and dump to DASD
- But: SCSI dump only supported for LPARs, not z/VM
- Preparation summary:
  - large SCSI disk (LPAR memory + 10MB)
  - fdisk /dev/sda
  - mke2fs /dev/sda1
  - mount /dev/sda1 /mnt
  - zipl -D /dev/sda1 -t /mnt
  - umount /mnt
Issue SCSI dump from HMC

- Select CPC image for LPAR to dump
- Goto Load panel
- Issue SCSI dump
  - FCP device
  - WWPN
  - LUN
NPIV

- N_Port Identifier Virtualization (NPIV)
- without NPIV: one WWPN for FCP channel
- with NPIV: unique WWPN for each FCP subchannel
- enables proper zoning in SAN fabrics
- enables proper LUN masking in storage devices
- security
- access control
LUN masking with NPIV

Storage server can identify Linux guests via WWPNs
SAN zoning with NPIV

- Different Linux guests in different zones

zone “green”

zone “red”

zone “blue”
NPIV requirements

- NPIV is available on System z servers.
  - FICON Express 2 adapter running with MCL003 on EC J99658
- z/VM
  - z/VM 5.2 or 5.3
  - z/VM 5.1 with the PTF for APAR VM63744
- Linux Distribution
  - Currently SLES9 SP3/4, SLES10, RHEL5 (LPAR mode or z/VM)
- NPIV-Capable Switch
  - only required for switch adjacent to System z
Performance considerations

Throughput for random readers

- **DS8300**
- **z990 LPAR**
- **SLES9 SP2**
  - 8 CPUs
  - 8 FICON
  - 8 FCP
  - 256 MB
- **lozone 3.96**

Higher performance with SCSI disks compared to ECKD
New features overview

- Blktrace for I/O and latency tracing
- Channel statistics from sysfs (2.6.26)
- Channel and fabric latencies in upstream code (2.6.27)
- Automatic port discovery (2.6.27)
- Message cleanup (2.6.27)
• “old” zfcp specific statistics only available as “add-on” patch
• new kernel infrastructure and tools: blktrace
• common I/O tracing infrastructure in Linux
• request sizes / latencies
• functional replacement for most of the zfcp specific statistics

<table>
<thead>
<tr>
<th></th>
<th>All Devices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ALL</td>
</tr>
<tr>
<td>Q2Q</td>
<td>0.0000000072</td>
</tr>
<tr>
<td>Q2I</td>
<td>0.000000359</td>
</tr>
<tr>
<td>I2D</td>
<td>0.000000933</td>
</tr>
<tr>
<td>D2C</td>
<td>0.000363719</td>
</tr>
<tr>
<td>Q2C</td>
<td>0.000395336</td>
</tr>
</tbody>
</table>

(Queued, Issued, Dispatched, Complete)
D2C == Dispatched to Complete
New statistics from sysfs

**Subchannel**

```bash
# cat /sys/class/scsi_host/host0/megabytes
16 1  read, written

# cat /sys/class/scsi_host/host0/requests
3963 37 2  input, output, control requests

# cat /sys/class/scsi_host/host0/seconds_active
2871
```

**FCP Channel utilization**

```bash
# cat /sys/class/scsi_host/host0/utilization
2 10 0  channel processor, channel bus, adapter
```

more channel data in `/sys/class/fc_host/host0/statistics/`
Channel and fabric latencies

- previously part of zfcp statistics add-on
- available through sysfs (2.6.27)

```bash
# cat /sys/block/sda/device/write_latency
273 4562 67446 32 616 9212 37

# cat /sys/block/sda/device/read_latency
129 77471 18507807 21 67 110541 3963

# cat /sys/block/sda/device/cmd_latency
92 98 190 23 28 52 2
```

- fabric: min, max, sum (micro seconds)
- channel: min, max, sum (micro seconds)
Automatic port discovery

- Discover and attach ports automatically
  - when setting adapter online,
  - on changes in SAN.

```
# cd /sys/bus/ccw/drivers/zfcp/0.0.181d/
# echo 1 > online
# ls -d 0x*
0x500308c141699001 0x5005076300cbb130 0x5005076303048335
0x500507630310c562 0x500507630e0202aa 0x500308c141699004
0x5005076300cc0b8e 0x5005076303098335 0x500507630313c562
```

- Manual trigger available:

```
# echo 1 > port_rescan
```

- Does not change handling of LUNs
- LUNs have to be attached manually:

```
# echo 0x401040C300000000 > 0x500507630310c562/unit_add
```
Message cleanup

- removed debug and trace messages
- removed information also available in sysfs or lszfpc
- standard format (zfcp: 0.0.XXXX: ...)

old

zfcp: The adapter 0.0.181d reported the following characteristics:
  WWNN 0x5005076400c2d09e, WWPN 0x5005076401e071b2, S_ID 0x00689313,
  adapter version 0x3, LIC version 0x170b, FC link speed 2 Gb/s
zfcp: Switched fabric fibrechannel network detected at adapter 0.0.181d.
zfcp: adapter 0.0.181d: no path
zfcp: adapter 0.0.181d: operational again

new

zfcp: 0.0.181d: Switched fabric fibrechannel network detected.
zfcp: 0.0.181d: no path
zfcp: 0.0.181d: operational again
References

- Supported devices
  http://www.ibm.com/systems/z/hardware/connectivity/products(fc.html

- Storage device interoperability
  http://www.ibm.com/systems/support/storage/config/ssic/index.jsp

- Linux on System z Documentation
  http://www.ibm.com/developerworks/linux/linux390/
  - Device Drivers, Features, and Commands
  - How to use FC-attached SCSI devices with Linux on System z
  - Using the Dump Tools

- Tuning hints & tips

- Device driver for IBM tape drives
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