Logical Volume Management for Linux on System z

Session 9282

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Agenda

- Logical volume management overview
  - RAID levels
  - Striping
  - Mirroring
  - Multipathing
- Multipathing with zFCP / SCSI
- Multipathing with DASD using PAV
- Outlook on future development
Redundant Arrays of Inexpensive / Independent Disks (RAID)

- Using multiple disks to share or replicate data to increase
  - Data integrity
  - Fault-tolerance
  - Throughput
  - Capacity

- Provides different configurations (RAID Level)

- Implemented as Software- or Hardware-RAID
RAID Level

- **Linear device (JBOD)**
  - Concatenate multiple physical disks to single virtual device

- **RAID-0 (striping)**
  - Data is split evenly across disks (round robin)
  - Fast and efficient (no redundant information stored)
  - No fault-tolerance

- **RAID-1 (mirroring)**
  - exact data copy to 2 or more disks
  - Fast on read slow on write
  - Fault-tolerance (redundant data)
  - Needs additional capacity
RAID Level (cont.)

- **RAID-2**
  - Stripe data at **bit level** across several disks
  - Use 'Hamming code' for error correction
  - Intended for use with no built-in error detection

- **RAID-3**
  - Stripe data at **byte level** across several disks
  - Parity stored on dedicated disk (bottleneck)
  - Cannot serve multiple requests simultaneously
  - Parity allows recovery of single disk failure

- **RAID-4 (Striping & Dedicated)**
  - Stripe data at **block level** across several disks
  - Otherwise similar to level 3
RAID Level (cont.)

- **RAID-5 (Striping & Distributed Parity)**
  - Distribute parity among disks
  - Otherwise similar to level 4

- **RAID-10 (Mirroring & Striping)**
  - Combination of RAID-1 and RAID-0
    (mirroring of striped device)
  - Good performance & Fault tolerance
Logical Volume Management (LVM) Terms

- **Physical volume (PV)**
  - Any kind of block device (DASD, SCSI,...)

- **Physical Extend (PE)**
  - Even sized parts of the physical volume (default size 4M)

- **Volume Group (VG)**
  - Pool of physical extends

- **Logical volume (LV)**
  - Virtual block device based on concatenated pooled PEs

- **Logical Extend (LE)**
  - Part of a logical volume
  - Same size as physical extend of the volume group
  - 1:1 mapping LE:(PV:PE)
LVM – Simple Example (linear device)

Volume Group 96MB

LV1
LE 0-5
6*4=24MB

LV2
LE 0-7
8*4=32MB

LV3
LE 0-9
10*4=40MB

PV1
PE 0-11
12*4 = 48MB

PV2
PE 0-11
12*4 = 48MB

Mapping LE->PV/PE

Logical Volume (LV)

Physical Volume (PV)

1PE = 1LE = 4MB (default size)

e.g. LV3:LE7 ->PV2:PE9
LVM environment for striping

- Performance improvement due to multiple small disks
- No fault-tolerance
- Data evenly split across disks
LVM setup for mirroring

- Same data on each mirror
- Fault-tolerance
  Failing mirror can be recovered non-disruptive
- Needs double (or more) storage capacity
- Enhanced real time capabilities available

**IBM announced a service delivered Data Mirroring Solution for Linux on System z**

[Link to IBM's data mirroring solution](http://www-03.ibm.com/systems/services/labservices/platforms/labservices_z.html)
LVM setup for multipathing

- Performance improvement due to path load sharing
- Path fault tolerance (path failover / failback)
- Designed to handle all kind of block devices
- No storage server fault tolerance
Linux LVM Architecture

- Logical Volume Management applications
  - dmsetup
    - low level logical volume management
  - LVM2
    - latest version of Logical Volume Manager
  - Multipath
    - multipath configuration tool
  - EVMS
    - Enterprise Volume Management System
Linux LVM Architecture (cont.)

- **Libdevmapper**
  library for interaction between user and kernel device mapper

- **Device Mapper**
  - Modular framework for stacking target drivers like
    - Linear target
    - Mirror target
    - Multipath target
  - Responsibilities
    - Discover set of associated devices
    - Create mapping table containing configuration information
    - Pass mapping table into kernel
    - Possibly save mapping information
SAN Addressing
Path to FCP device

- **Device Number**
  (adapter busid)
  e.g. 0.0.190e

- **Worldwide Port Name**
  (WWPN)
  e.g. 0x500507630300c562

- **Logical Unit Number**
  (LUN)
  e.g. 0x401040ae00000000
Multipathing with zFCP / SCSI Configuration

- **SCSI disk configuration (first path)**
  with bus ID 0.0.190e (X), WWPN 0x500507630300c562 (1) and LUN 0x401040ae00000000 (A).
  - Change to adapter directory
    `cd /sys/bus/ccw/drivers/zfcp/0.0.190e`
  - Set the adapter to online
    `0.0.190e # chccwdev -e 0.0.190e`
  - Check for messages (in '/var/log/messages')
    ```
    scsi2 : zfcp
    zfcp: The adapter 0.0.190e reported the following characteristics:
    WWNN 0x5005076400c2d09e, WWPN 0x5005076401a07fd4, S_ID 0x00688a13,
    adapter version 0x3, LIC version 0x606, FC link speed 2 Gb/s
    zfcp: Switched fabric fibrechannel network detected at adapter 0.0.190e.
    ```
  - Add target port to FCP adapter
    `0.0.190e # echo 0x500507630300c562 > port_add`
Multipathing with zFCP / SCSI Configuration (cont.)

- Change to newly created port directory
  
  
  ```
  0.0.190e # cd 0x500507630300c562/
  ```

- Add FCP LUN to that port
  
  ```
  0.0.190e/0x500507630300c562 # echo 0x401040ae00000000 > unit_add
  ```

- Find new messages
  
  ```
  Vendor: IBM Model: 2107900 Rev: .216
  Type: Direct-Access ANSI SCSI revision: 05
  SCSI device sda: 10485760 512-byte hdwr sectors (5369 MB)
  sda: Write Protect is off
  SCSI device sda: drive cache: write back
  sda: unknown partition table
  sd 2:0:0:0: Attached scsi disk sda
  sd 2:0:0:0: Attached scsi generic sg0 type 0
  ```

- SCSI disk is now available
  
  ```
  0.0.190e # lsscsi
  [2:0:0:0] disk IBM 2107900 .216 /dev/sda
  ```
Multipathing with zFCP / SCSI
Configuration (cont.)

- SCSI disk configuration (remaining paths)
  with additional bus ID 0.0.520e (Y), additional WWPN 0x500507630303c562 (2)

```bash
# cd /sys/bus/ccw/drivers/zfcp/0.0.190e/
0.0.190e # echo 0x500507630303c562 > port_add
0.0.190e # echo 0x401040ae00000000 > /unit_add
0.0.190e # cd .. zfcp # cd 0.0.520e
0.0.520e # echo 0x500507630300c562 > port_add
0.0.520e # echo 0x401040ae00000000 > /unit_add
0.0.520e # echo 0x500507630303c562 > port_add
0.0.520e # echo 0x401040ae00000000 > /unit_add
0.0.520e # lsscsi
[1:0:0:0] disk IBM 2107900 .216 /dev/sdc
[1:0:1:0] disk IBM 2107900 .216 /dev/sdd
[2:0:0:0] disk IBM 2107900 .216 /dev/sda
[2:0:1:0] disk IBM 2107900 .216 /dev/sdb
```
Multipathing with zFCP
Multipath Configuration

- **Start multipathd**
  ```
  linux:~ # /etc/init.d/multipathd start
  ```

- **load dm-multipath module, activate mp-tools**
  ```
  linux:~ # /etc/init.d/boot.multipath start
  ```

- **Check for multipath configuration**
  ```
  linux:~ # multipath -ll
  36005076303ff5620000000000010aeIBM,2107900
  [size=5G][features=1 queue_if_no_path][hwhandler=0]
  \_ round-robin 0 [prio=4][active]
  \_ 2:0:0:0 sda 8:0 [active][ready]
  \_ 2:0:1:0 sdb 8:16 [active][ready]
  \_ 1:0:0:0 sdc 8:32 [active][ready]
  \_ 1:0:1:0 sdd 8:48 [active][ready]
  ```

- **Device node provided by mp-tools**
  ```
  linux:~ # ls -l /dev/mapper/
  total 0
  brw------- 1 root root 253, 0 Jan 4 11:47 36005076303ff5620000000000010ae
  lrwxrwxrwx 1 root root 16 Jan 4 11:15 control -> ../device-mapper
  ```
Multipathing with zFCP Partitioning

• **Write partition table to disk**
  
  ```
  linux:~ # fdisk /dev/sda
  ```

  --> **follow instructions to create primary partition**

• **Check device nodes**
  
  ```
  linux:~ # ls -l /devmapper/
  total 0
  brw------- 1 root root 253, 0 Jan 4 12:03 36005076303ffe562000000000000010ae
  brw------- 1 root root 253, 1 Jan 4 12:03 36005076303ffe562000000000000010ae-part1
  ```
Multipathing with DASD using static PAV

- One base path (blue) to physical device
- Additional alias paths (green)
- Increased performance and path-fault tolerance
- Needs additional subchannels
Multipathing with DASD HW configuration

- **PAV configuration on Storage Server**
  
  please refer to
  
  *IBM TotalStorage Enterprise Storage Server Web Interface User’s Guide, SC26-7448*

- **zSeries configuration (IOCP)**

  *************************************************** *******************
  * DEFINE 3390-9 BASE AND ALIASES ADDRESS             *
  * 16 BASE ADDRESS, 3 ALIASES PER BASE                 *
  *************************************************** *******************

  \[\text{IODEVICE ADDRESS}=(7000,016), \text{CUNUMBR}=(5000), \text{STADET=Y}, \text{UNIT=3390B}\]

  \[\text{IODEVICE ADDRESS}=(70D0,048), \text{CUNUMBR}=(5000), \text{STADET=Y}, \text{UNIT=3390A}\]
Multipathing with DASD
DASD configuration

- **DASD parameters / attributes**
  - 'nopav' to disable pav enablement call and device re-probing in DASD / CIO
  - **sysfs attributes** in `/sys/bus/ccw/device/<busid>/`
    - vendor: The vendor of the machine (also known as manufacturer).
    - alias: '0' for base device / '1' for alias device
    - uid: Containing a string like 'www.xxx.yyy.zzz' where
      - www = vendor (also known as manufacturer)
      - xxx = serial (serial of the machine)
      - yyy = subsystem id (address of the subsystems)
      - zzz = unit address (address of the physical disk)

- **DASD device configuration (base device)**
  - Set base devices online
    
    ```
    # chccwdev -e 0.0.7000
    ```
  - Check for messages (in `/var/log/messages`)
    
    ```
    dasd(eckd): 0.0.7000: 3390/0A(CU:3990/01) Cyl:3339 Head:15 Sec:224
dasd_erp(3990): 0.0.7000: EXAMINE 24: No Record Found detected
dasd(eckd): 0.0.7000: volume analysis returned unformatted disk
    ```
Multipathing with DASD
DASD configuration (cont.)

- **Low level format base device**
  - get device name using 'lsdasd'
    
    ```bash
    # lsdasd
    ```
  - Format device
    
    ```bash
    # dasdfmt -b 4096 -y -p /dev/dasdb
    cyl 5 of 5
    Finished formatting the device.
    Rereading the partition table... ok
    ```

- **Write partition table**
  
  ```bash
  # fdasd -a /dev/dasdb
  auto-creating one partition for the whole disk...
  writing volume label...
  writing VTOC...
  rereading partition table...
  ```
Multipathing with DASD
DASD configuration (cont.)

• Find new messages
  dasd(eckd): 0.0.7000: (4kB blks): 2404080kB at 48kB/trk
  compatible disk layout
  dasdb: unknown partition table
  dasdb:VOL1/ 0X7000:
  dasdd:VOL1/ 0X7000: dasdd1

• DASD device configuration
  (alias devices)

  # chccwdev -e 0.0.70d0-0.0.70d2
Multipathing with DASD
Multipath configuration

- **Start multipathd**
  
  ```
  # /etc/init.d/multipathd start
  ```

- **load dm-multipath module, activate mp-tools**
  
  ```
  # /etc/init.d/boot.multipath start
  ```

- **Check for multipath configuration**
  
  ```
  # multipath -ll
  IBM.750000000092461.2a00.1a IBM,S/390 DASD ECKD
  [size=2.3G][features=0][hwhandler=0]
  __ round-robin 0 [prio=4][undef]
  __ 0:0:10778:0 dasdb 94:4 [undef][ready]
  __ 0:0:10927:0 dasdc 94:8 [undef][ready]
  __ 0:0:10778:0 dasdd 94:12 [undef][ready]
  __ 0:0:10927:0 dasde 94:16 [undef][ready]
  ```

- **Device node provided by mp-tools**
  
  ```
  # ls -l /dev/mapper/*
  brw-rw---- 1 root disk 253, 0 Oct 19 17:02 /dev/mapper/IBM.750000000092461.2a00.1a
  brw-rw---- 1 root disk 253, 1 Oct 19 17:10 /dev/mapper/IBM.750000000092461.2a00.1ap1
  ```
Multipathing with DASD Performance (first glance)

Static PAV with bonnie (on prototype)

Number of devices (Base + x Alias)

Throughput in KB/s

Char Write
Char Read
Block Write
Block Read
Multipathing with DASD Pitfalls

- Make sure the device is formatted and partitioned prior to multipath-setup
- Be careful when formatting / partitioning devices currently in use (see howto)
- Use `cio_ignore` since base detection does re-probing (performance issue during ipl)
- Use blacklist in multipath-tools to exclude no-PAV DASD devices
## Disk usage
### ECKD and SCSI Comparison

<table>
<thead>
<tr>
<th></th>
<th>ECKD DASD</th>
<th>SCSI Disk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration</td>
<td>IOCDS / zVM (operator)</td>
<td>IOCDS / zVM (operator &amp; linux admin)</td>
</tr>
<tr>
<td>Access Method</td>
<td>SSCH / CCW</td>
<td>QDIO</td>
</tr>
<tr>
<td>Block Size (Byte)</td>
<td>512, 1K, 2K, 4K</td>
<td>512</td>
</tr>
<tr>
<td>Disk Size</td>
<td>&lt; ~57GB</td>
<td>?</td>
</tr>
<tr>
<td>Formatting (low level)</td>
<td>dasdfmt</td>
<td>not necessary</td>
</tr>
<tr>
<td>Partitioning</td>
<td>fdasd</td>
<td>fdisk</td>
</tr>
<tr>
<td>File System</td>
<td>mke2fs (or others)</td>
<td>mount</td>
</tr>
<tr>
<td>Access</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Horst Hummel, IBM STG-LTC Boeblingen*
Useful Commands

- **lscss**
  list channel subsystem devices

- **lsdasd**
  list DASD related device information

- **dasdview**
  display extended DASD information

- **lszfcp**
  list information about zfcp adapters, ports, and units

- **lsscsi**
  list all scsi devices

- **chccwdev -e/-d**
  enable/disable ccw device

- **dasdfmt**
  low level format for DASD (ECKD) devices

- **fdasd**
  partitioning tool for DASD

- **fdisk**
  partitioning tool for SCSI

- **multipath -ll**
  display multipath configuration
Outlook (subject to change)

- Enhancements in common block device stack to allow cancellation of a request
- Upstream integration of real time mirror solution
- PAV / HyperPAV support in DASD device driver
DASD Next Generation Multipath using HyperPAV support

- Pool of ALIAS devices can be used for each base device on demand
- Loadbalancing done in DASD device driver
- Configuration autodetection
DASD Next Generation Multipathing Configuration

- PAV configuration on Storage Server
- zSeries configuration (IOCP)
- Basic DASD configuration
- That’s it – nothing else to do
  - no multipath configuration needed
  - no formatting / partitioning related pitfalls

HyperPAV simplifies systems management and improves performance using an on demand I/O model
DASD Next Generation Multipathing
Performance Single Disk Test – Sequential DIO - 700MB file size - 256MB Memory

Throughput for initial writers

Throughput for readers
Useful links

- Linux on System z – developerworks page
  http://www-128.ibm.com/developerworks/linux/linux390/

- Device Drivers, Features and Commands (SC33-8411-00)

- How to Improve Performance with PAV (SC33-8414-00)

- How to use FC-attached SCSI devices with Linux on System z (SC33-8413-00)

- Device-mapper development
  http://sourceware.org/dm/

- LVM HOWTO
  http://tldp.org/HOWTO/LVM-HOWTO/
Questions

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