Logical Volume Management for Linux on System z

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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 to single virtual disk
- **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 drives
  - Otherwise similar to level 3

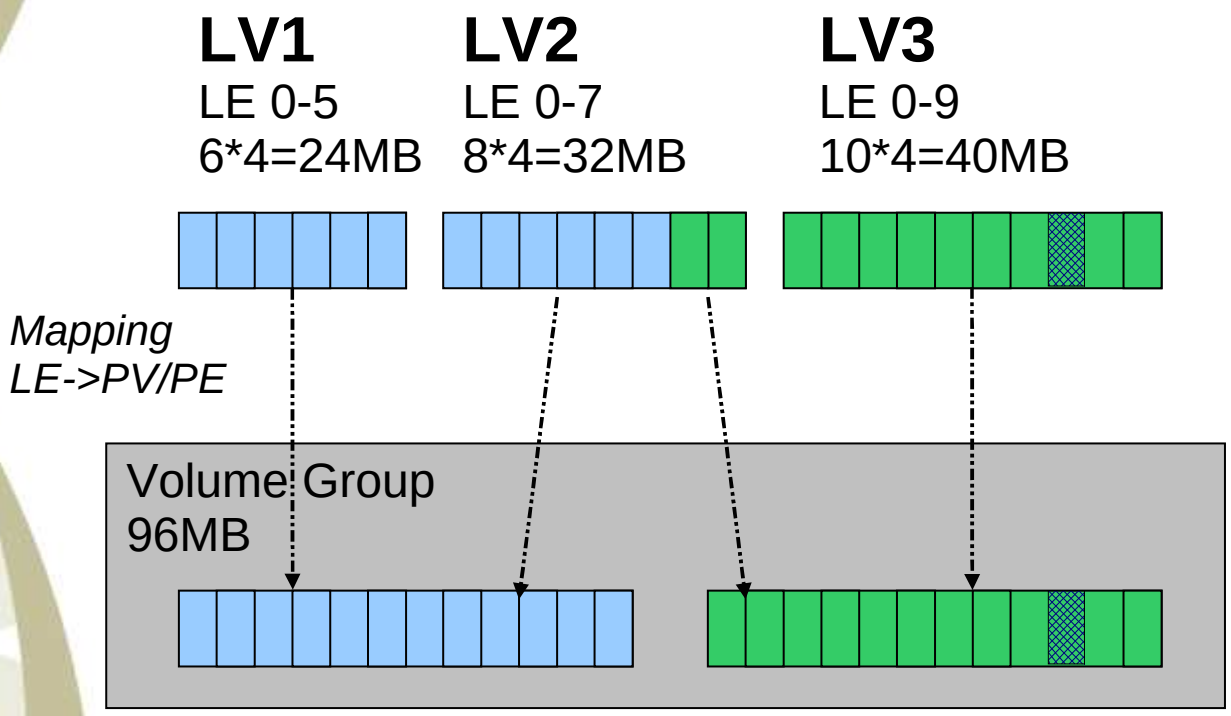
RAID Level (cont.)

- **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
- **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)



Logical Volume (LV)

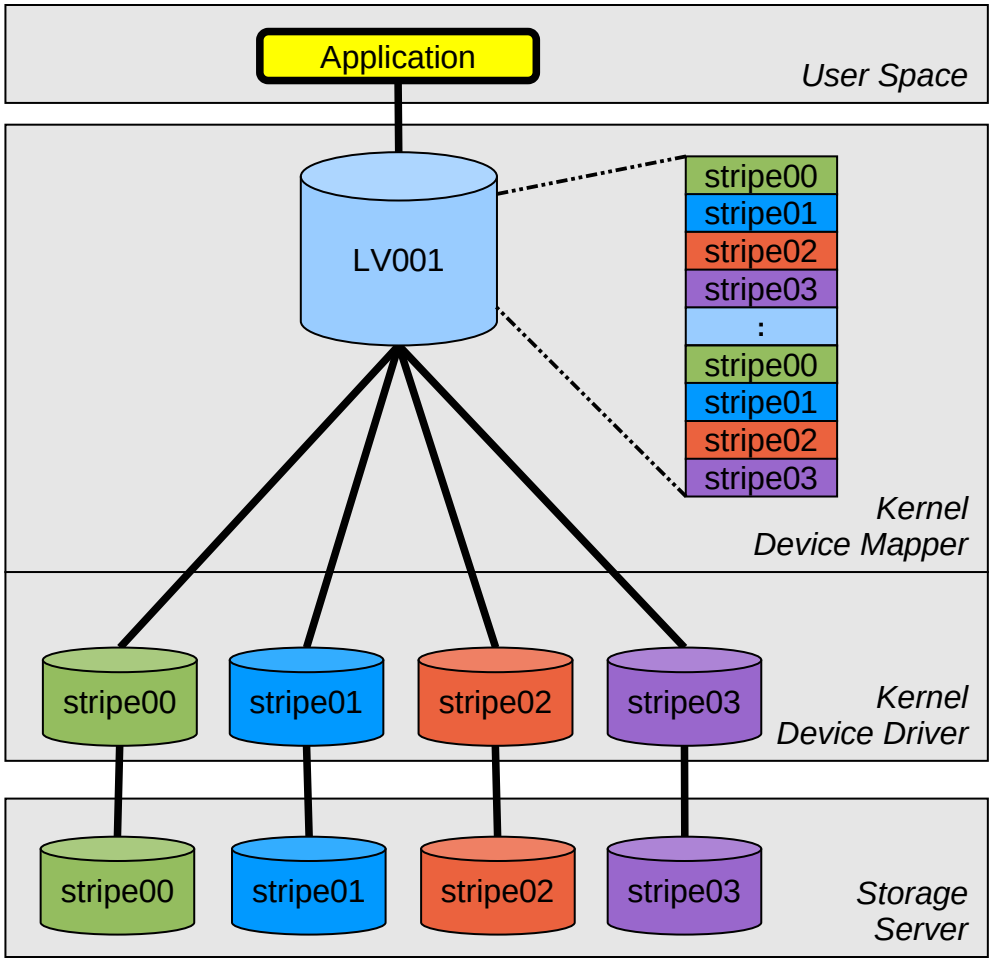
e.g.
LV3:LE7
->PV2:PE9

Physical Volume (PV)

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

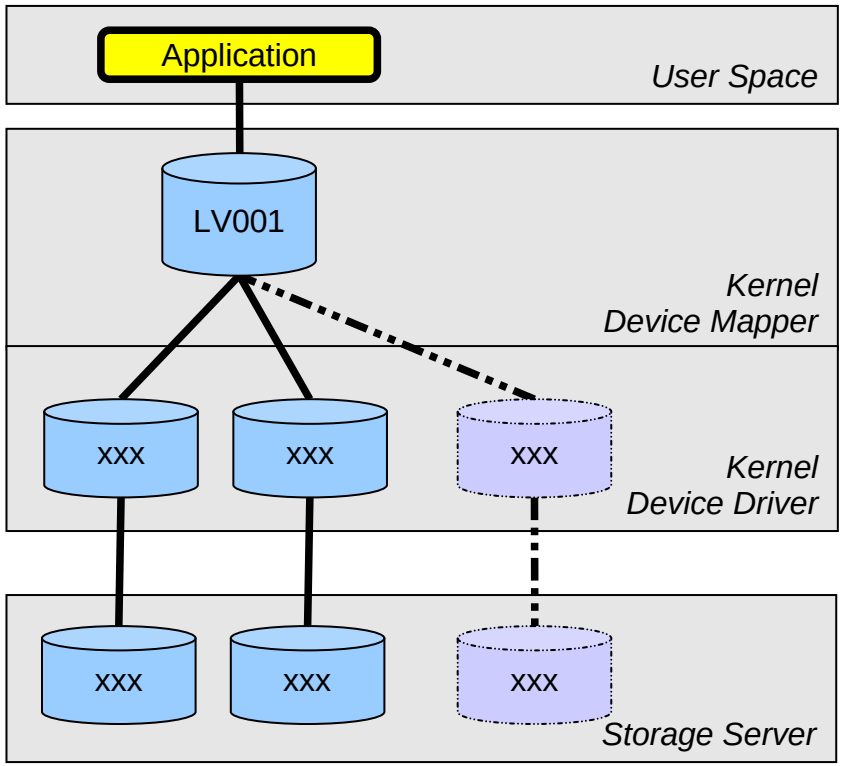
LVM environment for striping

- Performance improvement due to multiple small disks
- No fault-tolerance
- Data evenly split across disks



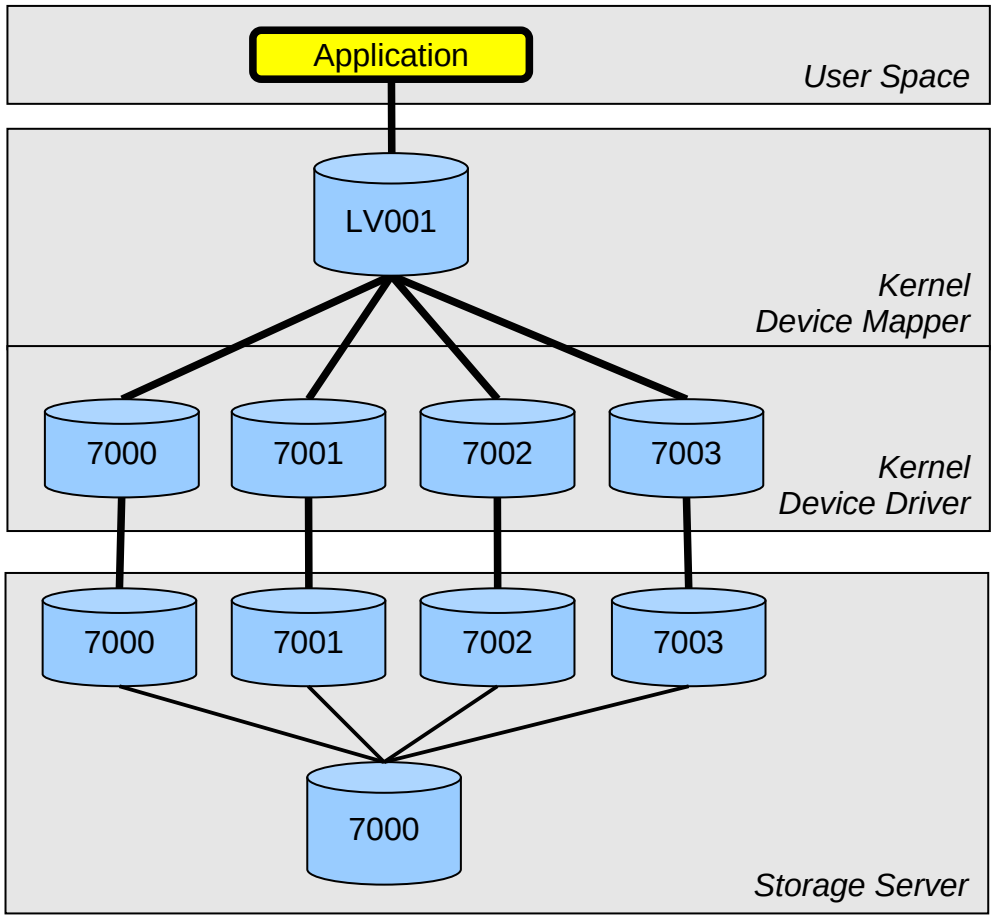
LVM setup for mirroring

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



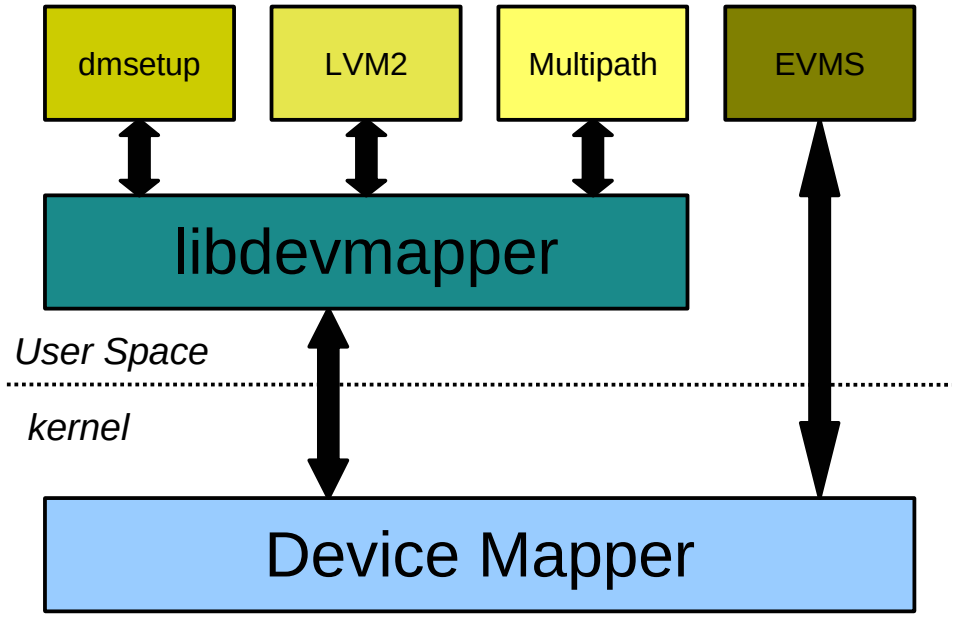
LVM setup for multipathing

- 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



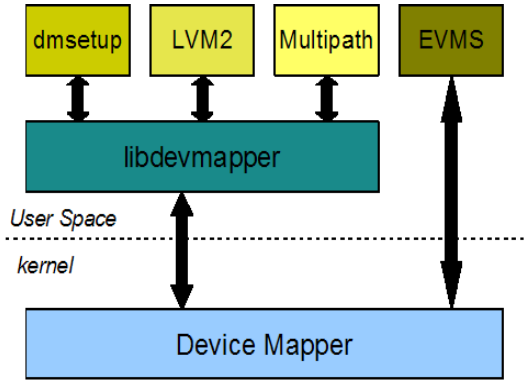
Linux Multipathing Architecture

- **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

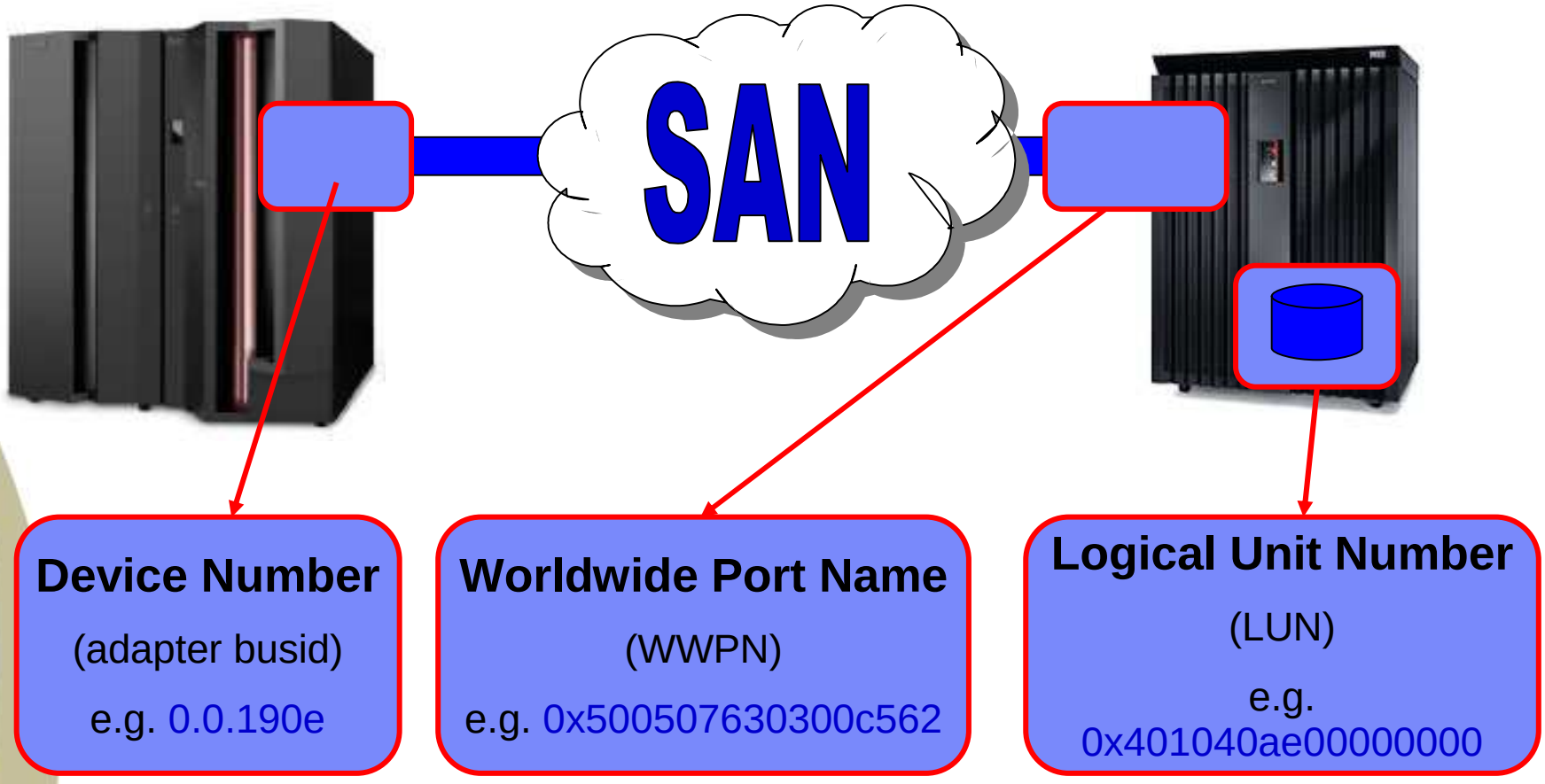


Linux Multipathing Architecture (cont.)

- **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

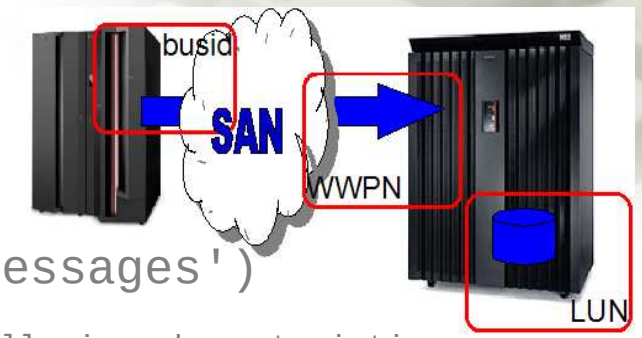


SAN Addressing
Path to FCP device



Multipathing with zFCP / SCSI Configuration

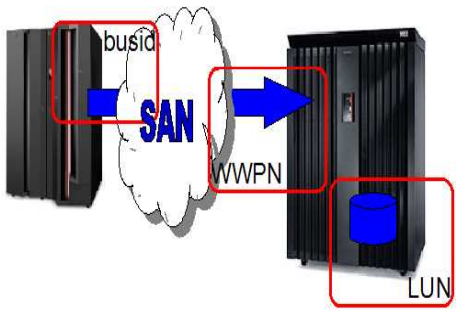
- **SCSI disk configuration (first path)**
  with bus ID 0.0.190e, WWPN0x500507630300c562 and LUN 0x401040ae00000000.



  - 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.)

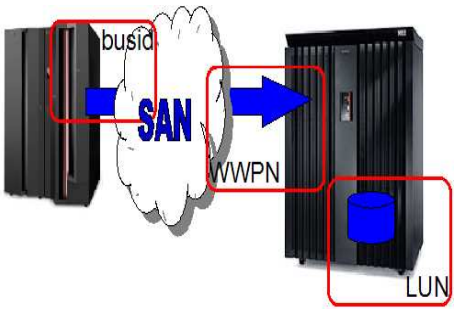
- Change to newly created port directory
  0.0.190e # cd 0x500507630300c562/
- Add FCP LUN to that port
  0.0.190e/0x500507630300c562 # echo 0x401040ae00000000 > unit_add
- Find new messages
  ```
  Vendor: IBM Model: 2107900 Rev: .216
  Type: Direct-Access ANSI SCSI revision: 05
  SCSI device sda: 10485760 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)

```
# cd /sys/bus/ccw/drivers/zfcp/0.0.190e/
0.0.190e # echo 0x500507630303c562 > port_add
0.0.190e # echo 0x401040ae00000000 > 0x500507630303c562/unit_add
0.0.190e # cd ..
zfcp # cd 0.0.520e/
0.0.520e # echo 0x500507630300c562 > port_add
0.0.520e # echo 0x401040ae00000000 > 0x500507630300c562/unit_add
0.0.520e # echo 0x500507630303c562 > port_add
0.0.520e # echo 0x401040ae00000000 > 0x500507630303c562/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
0.0.520e #
```



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
36005076303ffc56200000000000010aeIBM,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 36005076303ffc56200000000000010ae
lrwxrwxrwx 1 root root 16 Jan 4 11:15 control -> ../device-mapper
linux:~ #
```

Multipathing with zFCP Partitioning

- **Write partition table to disk**

  linux:~ # fdisk /dev/sda

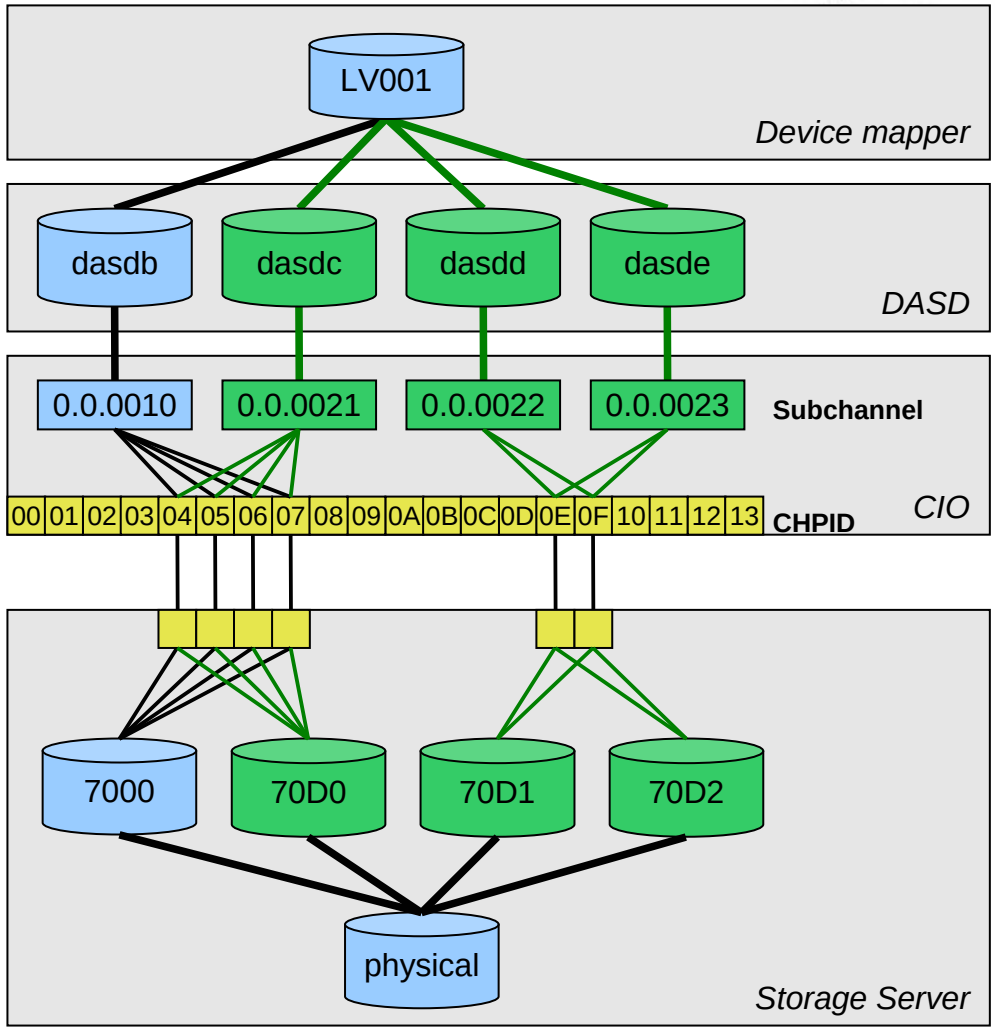
  -> follow instructions to create primary partition

- **Check device nodes**

```
linux:~ # ls -l /dev/mapper/
total 0
brw------- 1 root root 253, 0 Jan 4 12:03 36005076303ffc56200000000000010ae
brw------- 1 root root 253, 1 Jan 4 12:03 36005076303ffc56200000000000010ae-
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
  IBMTotalStorage 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                        *
**************************************************************
IODEVICE ADDRESS=(7000,016),CUNUMBR=(5000),STADET=Y,UNIT=3390B
IODEVICE ADDRESS=(70D0,048),CUNUMBR=(5000),STADET=Y,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 (if not already done)**
  - **get device name using 'lsdasd'**
    ```
    # lsdasd
    ```
  - **Format device**
    ```
    # dasdfmt -b 4096 -y -p /dev/dasdb

    cyl     5 of     5 ############################################################|
    100%

    Finished formatting the device.
    Rereading the partition table... ok
    ```
- **Write partition table (if not already done)**
  ```
  # 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
```

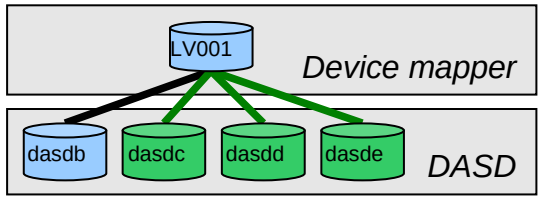
- **DASD device configuration (alias devices)**

```
# chccwdev -e 0.0.70d0-0.0.70d2
# lsdasd
```

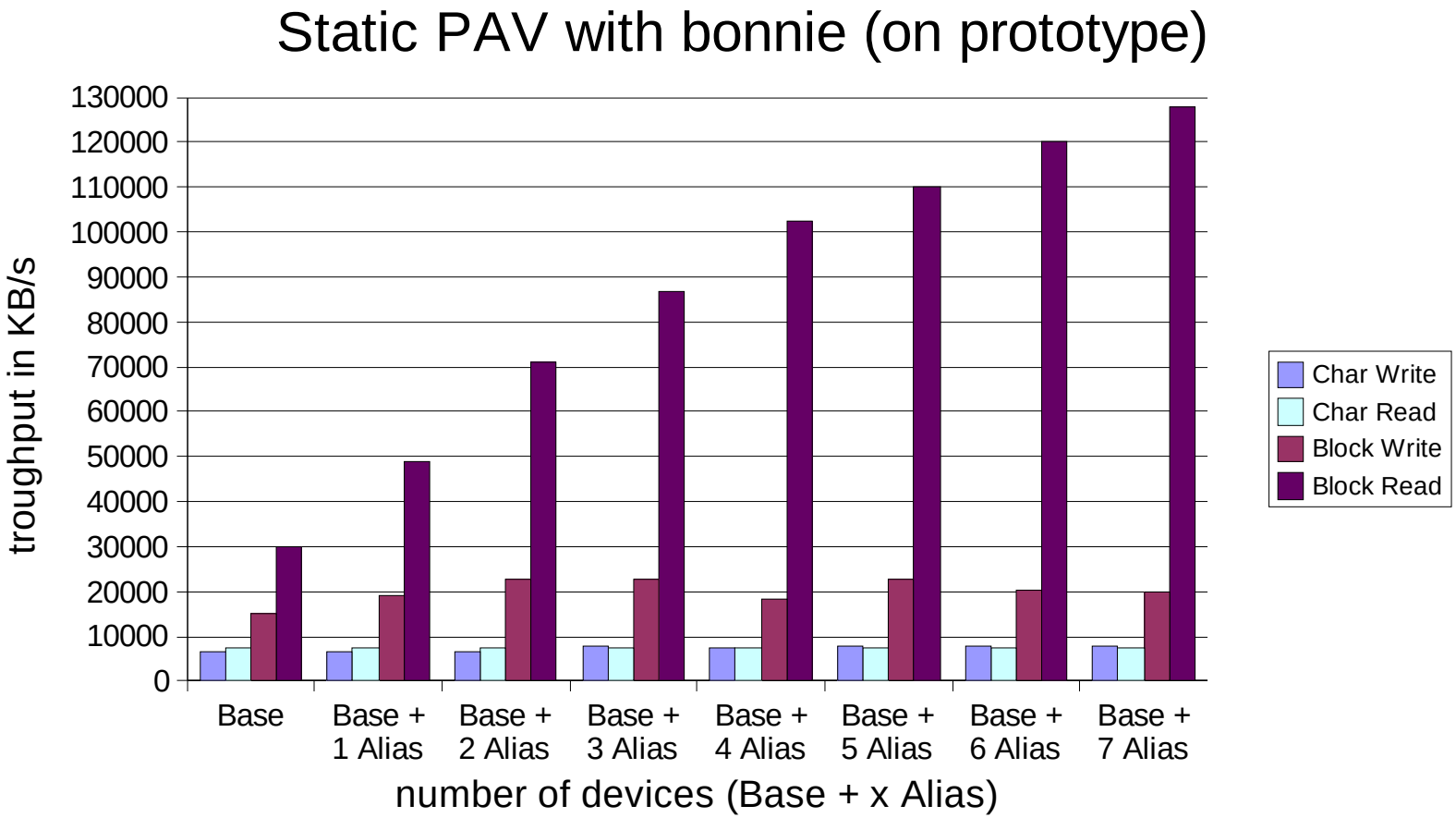
Multipathing with DASD
Multipath configuration

- **Device-mapper configuration**
  - Load dm_multipath module (if not already available)
    ```
    # modprobe dm_multipath
    ```
  - Use multipath command to automatically detect paths to device
    ```
    # multipath
    create: IBM.75000000092461.2a00.1a 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]
    ```
  - Access to multipath device

    device nodes for the multipath device are available at '/dev/mapper'
    ```
    # ls -l /dev/mapper/*
    brw-rw---- 1 root disk 253, 0 Oct 19 17:02 /dev/mapper/IBM.75000000092461.2a00.1a
    brw-rw---- 1 root disk 253, 1 Oct 19 17:10 /dev/mapper/IBM.75000000092461.2a00.1ap1
    ```



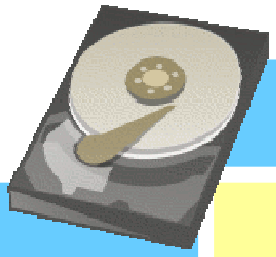
Multipathing with DASD Performance (first glance)



Multipathing with DASD Pitfalls

- Make sure the device is formatted and partitioned prior to mulitpath-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



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

Useful Commands

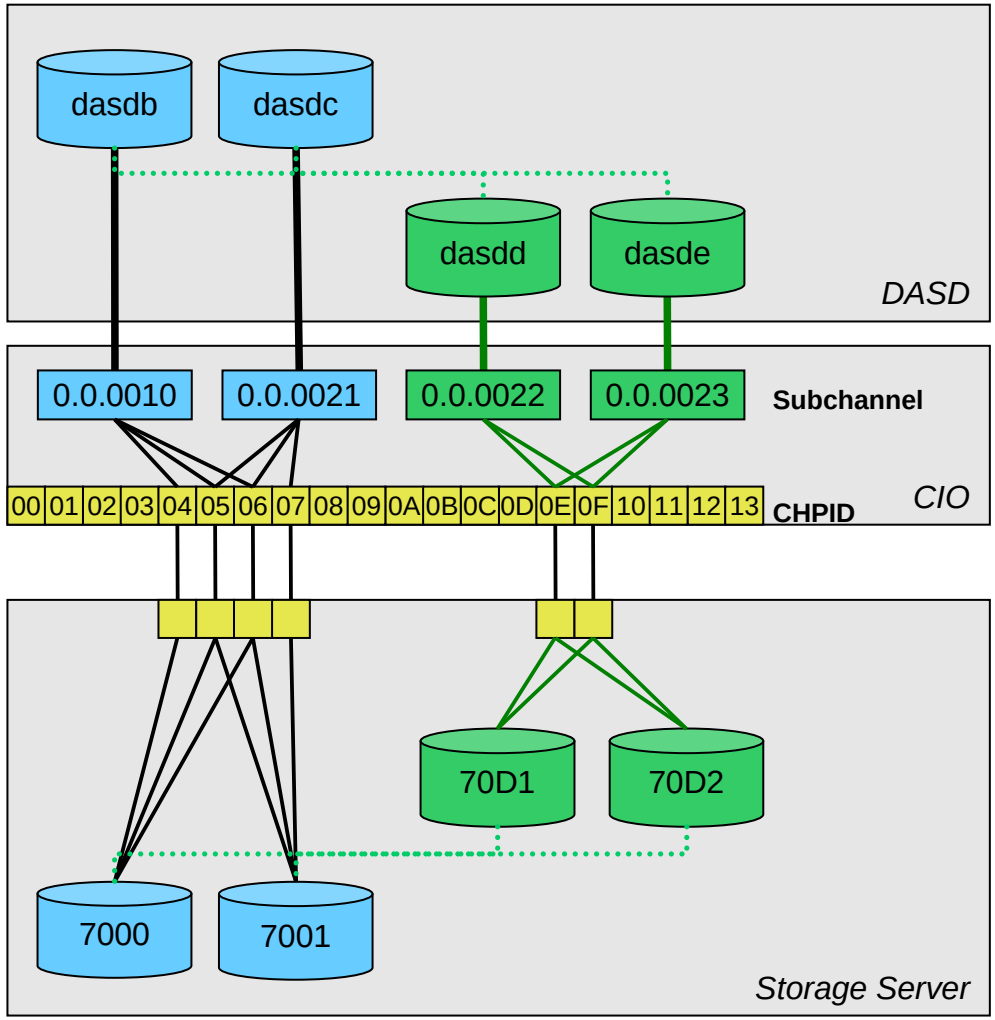
- **`lscss`**
  list channel subsystem devices
- **`lsdasd`**
  list DASD related device information
- **`dasdview`**
  display extended DASD information
- **`lszfcp`**
  list information about zfcp adapters, ports, and units
- **`lsscsi`**
  list all scsi devices
- **`chccwdev -e/-d`**
  enable/disable 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 Multipathing using HyperPAV support

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



DASD Next Generation Multipathing Configuration

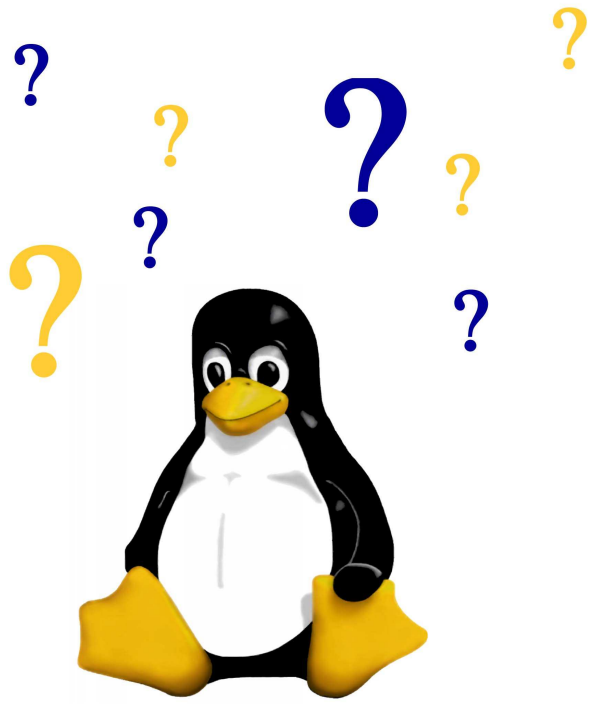
- **PAV configuration on Storage Server**
- **zSeries configuration (IOCP)**
- **Basic DASD configuration**
- **That's it – nothing else to do**
  - no multipath configuration needed
  - no formatting / partitioning related pitfalls

HyperPAV simplifies systems management and improves performance using an on demand I/O model

Useful links

- Linux on System z – developerworks page
  http://www-128.ibm.com/developerworks/linux/linux390/
- Device Drivers, Features and Commands (SC33-8289-03)
  http://download.boulder.ibm.com/ibmdl/pub/software/dw/linux390/docu/l26cdd03.pdf
- How to Improve Performance with PAV (*SC33-8292-01)*
  http://download.boulder.ibm.com/ibmdl/pub/software/dw/linux390/docu/l26chp01.pdf
- How to use FC-attached SCSI devices with Linux on System z (SC33-8287-00)
  http://download.boulder.ibm.com/ibmdl/pub/software/dw/linux390/docu/l26cts02.pdf
- *Device-mapper development*
  http://sourceware.org/dm/
- *LVM HOWTO*
  http://tldp.org/HOWTO/LVM-HOWTO/

Questions



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