Making Your Penguins Fly

Introduction to SCSI over FCP for Linux on System z

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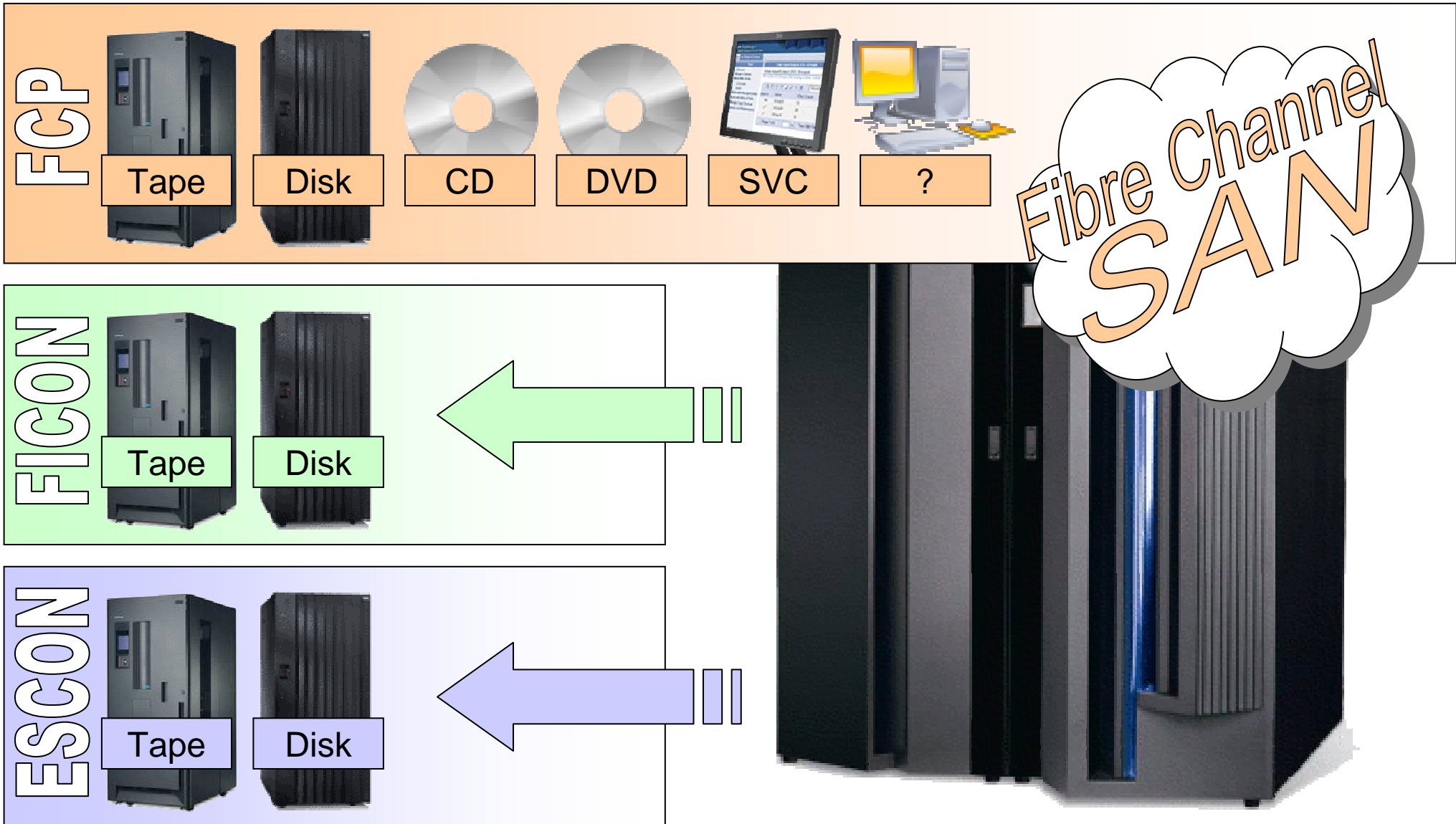**Share Baltimore, Maryland**
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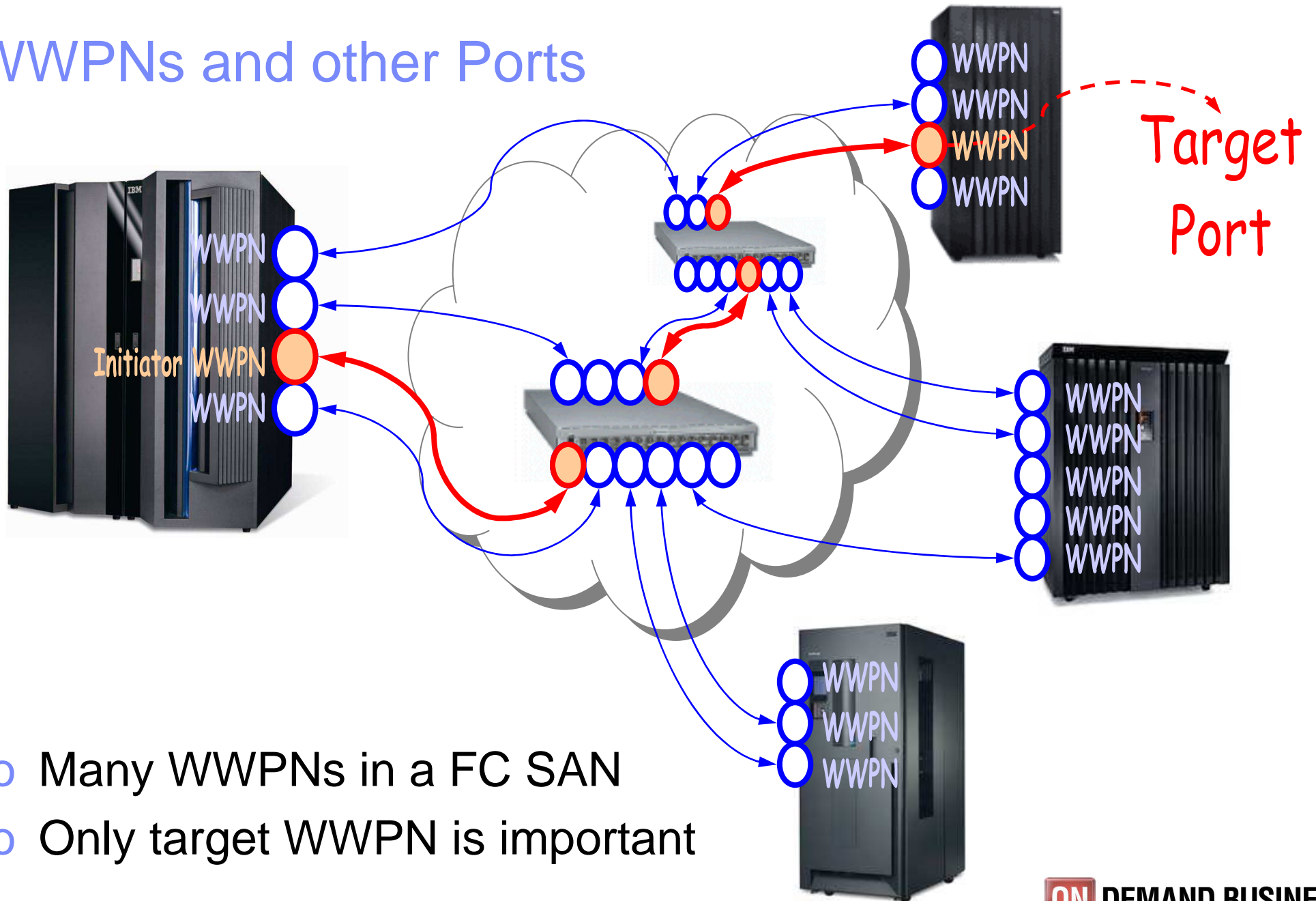
IBM

Making Your Penguins Fly – Flight Schedule

o SAN & SAN integration

o Addressing basics

o Requirements

o zfcp device driver

o Why FCP?

o Configuration

o Multipathing

o NPIV

o SAN Discovery Tool

o SCSI IPL/Dump

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System z in a SAN – Sharing Storage Resources

FCP

| Tape | Disk | CD | DVD | SVC | ? |

Fibre Channel SAN

FICON

| Tape | Disk |

ESCON

| Tape | Disk |

WWPNs and other Ports

Target Port

WWPN
WWPN
WWPN
WWPN

WWPN
WWPN
Initiator WWPN
WWPN

WWPN
WWPN
WWPN
WWPN
WWPN

WWPN
WWPN
WWPN

o Many WWPNs in a FC SAN

o Only target WWPN is important

Navigating in a SAN

Fibre Channel SAN

Bus Identifier
(busid)
e.g. 0.0.e962

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

Logical Unit Number
(LUN)
e.g. 0x4012403400000000

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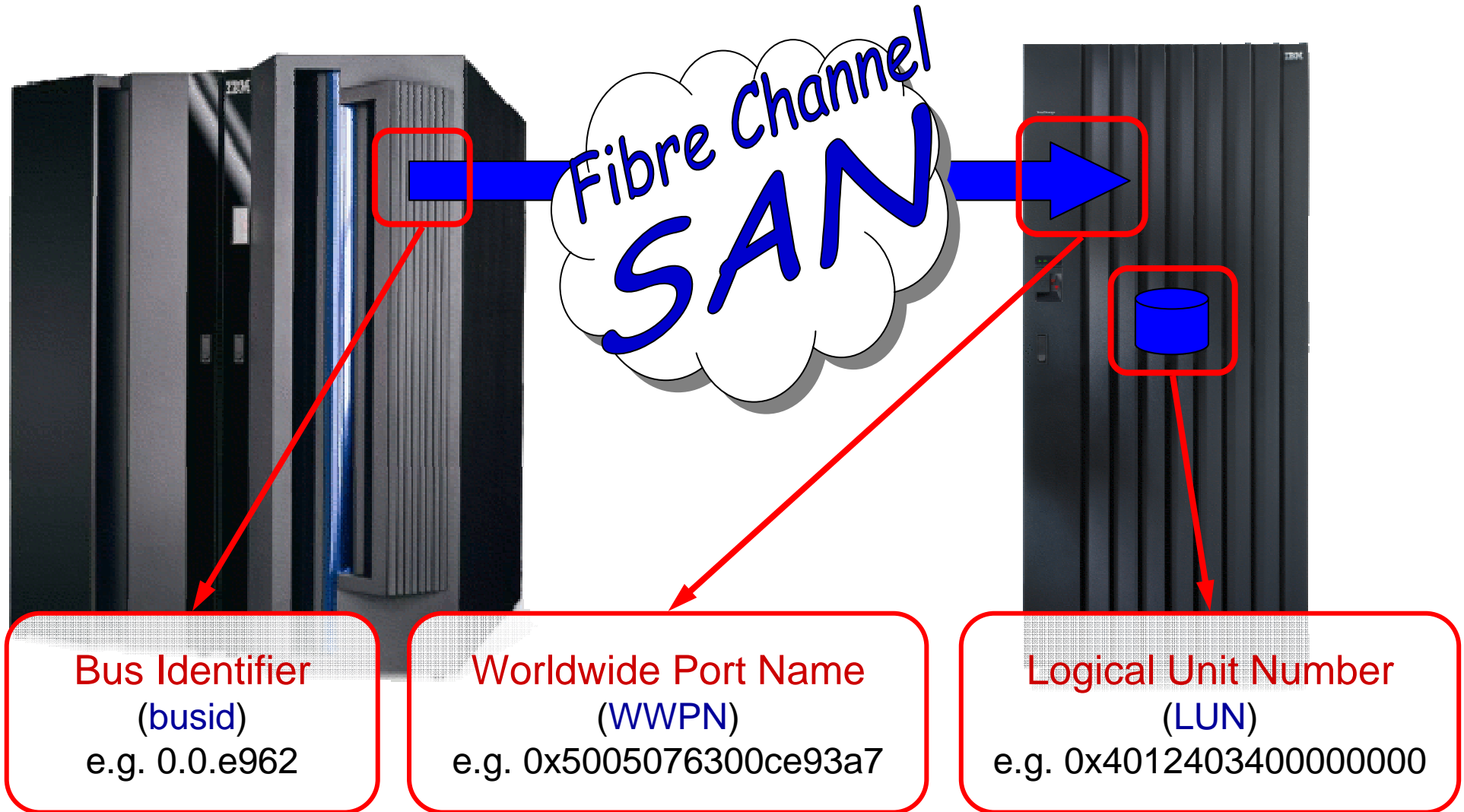
zSeries in a SAN – Hardware Requirements

o IBM zSeries 800, 890, 900 or 990

o IBM System z9 EC/BC
(NPIV z9-only)

o FICON or FICON Express
adapter cards

o CHPID type FCP

o FC fabric switch

o FC storage subsystem

o Optional: FCP-SCSI bridge
+ SCSI devices

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Software Requirements

o SCSI (IPL) with z/VM

- z/VM Version 4.4 (PTF UM30989) or newer

- z/VM Version 5.2 (current version)

    o SUSE Linux Enterprise Server 8 (SLES8)

        - Service Pack 4

    o SUSE Linux Enterprise Server 9 (SLES9)

        - Service Pack 3

    o SUSE Linux Enterprise Server 10 (SLES10)

        - Available

    o Red Hat Enterprise Linux 3 (RHEL3)

        - Update 8

    o Red Hat Enterprise Linux 4 (RHEL4)

        - Update 4

    o Red Hat Enterprise Linux 5 (RHEL5)

        - Outlook 2007

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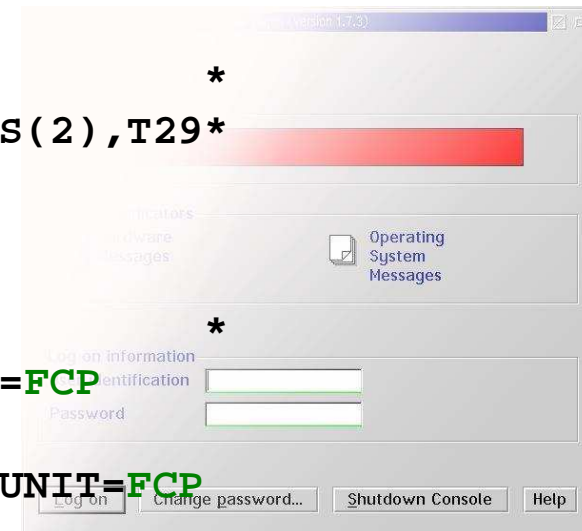# IOCDS – FCP Configuration Sample

```
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


CHPID PATH=(CSS(2),58),SHARED,                                   *
      PARTITION=((T29LP32,T29LP33),(=)),PCHID=500,TYPE=FCP
CNTLUNIT CUNUMBR=1781,PATH=((CSS(2),58)),UNIT=FCP
IODEVICE ADDRESS=(1780,064),UNITADD=00,CUNUMBR=(1781),UNIT=FCP
```
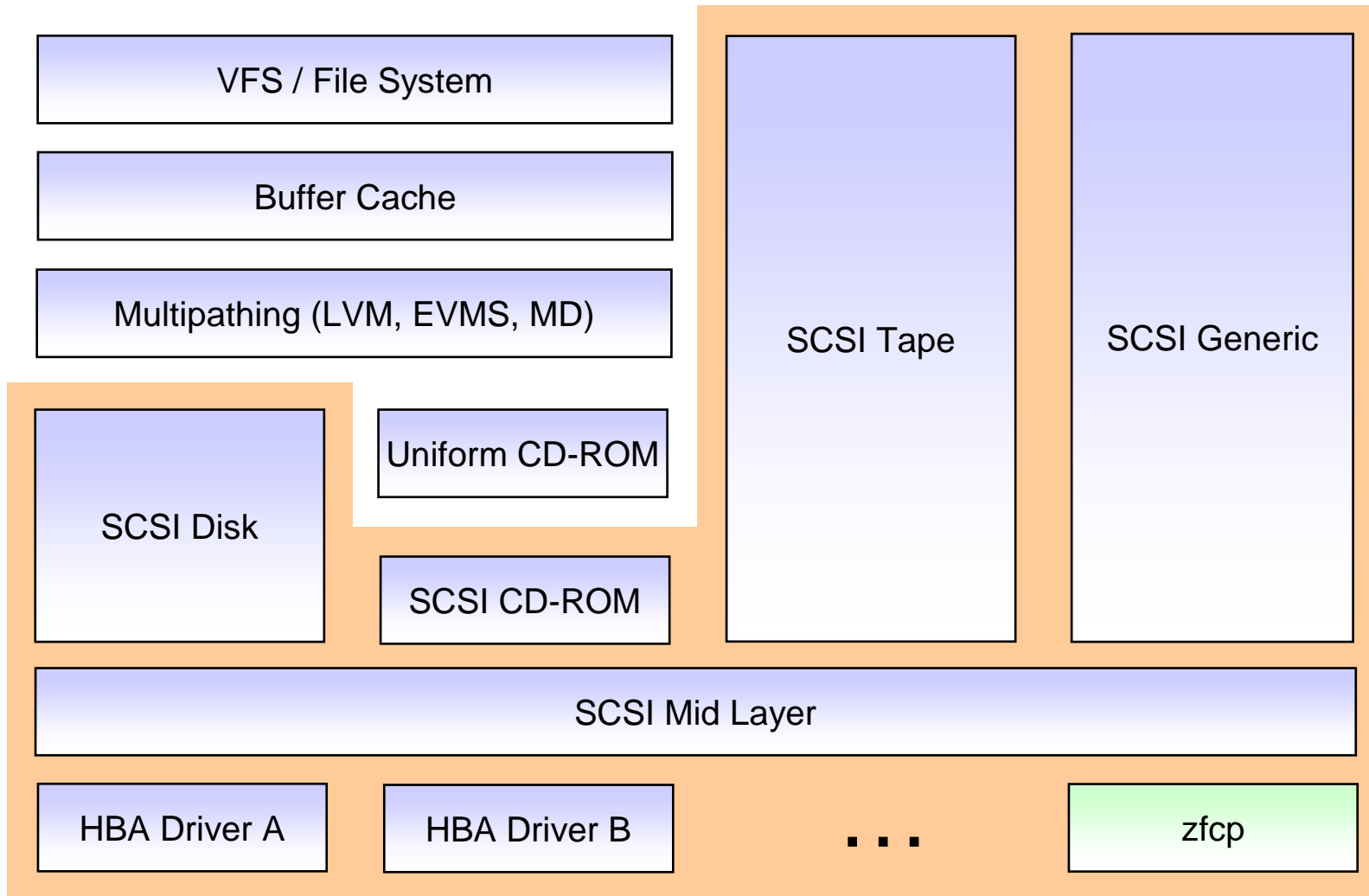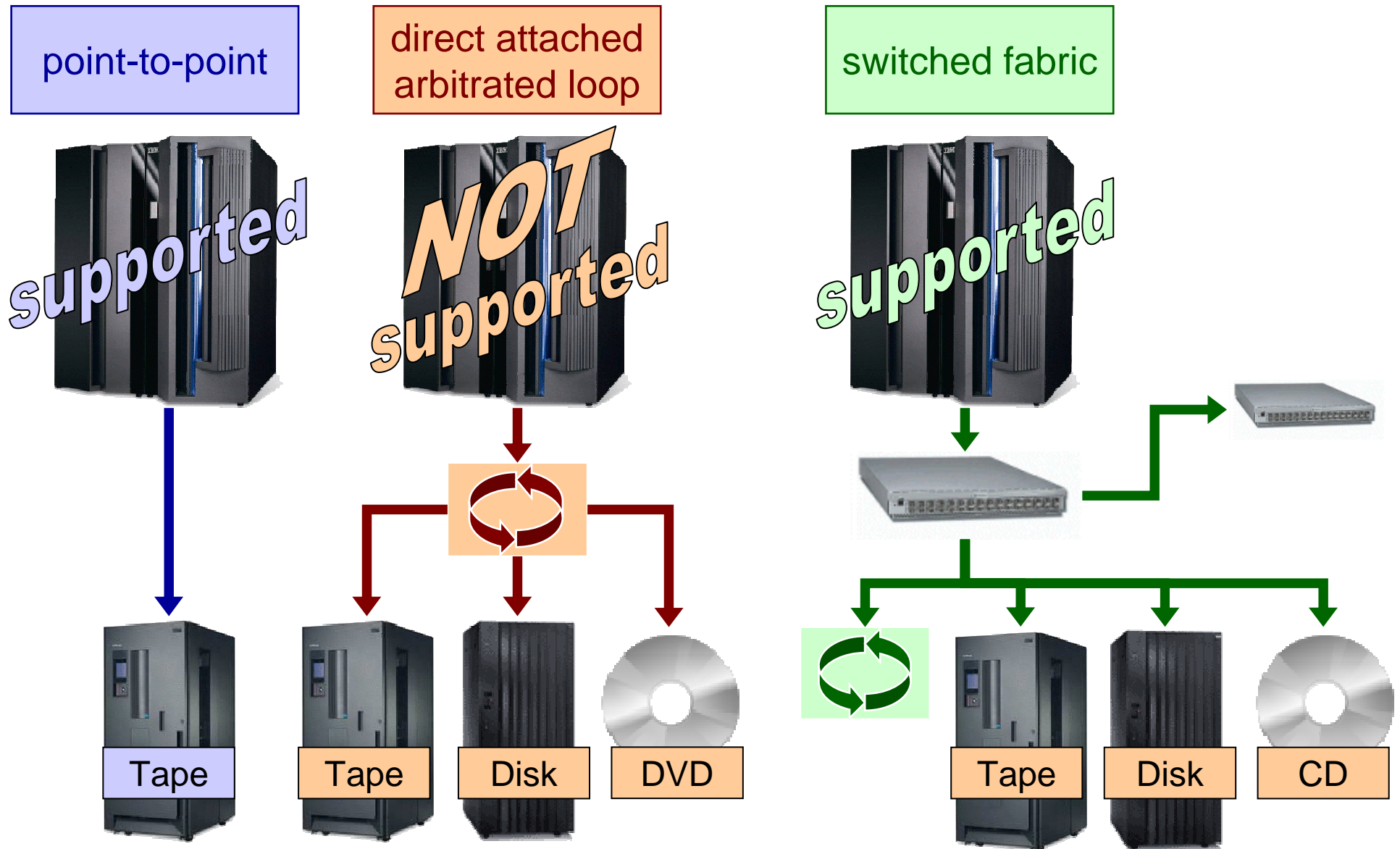
Linux SCSI Stack

SCSI Stack

| VFS / File System |
| Buffer Cache |
| Multipathing (LVM, EVMS, MD) |

SCSI Disk

Uniform CD-ROM

SCSI CD-ROM

SCSI Tape

SCSI Generic

SCSI Mid Layer

HBA Driver A | HBA Driver B | . . . | zfcp

zfcp's Task in the Linux SCSI Stack

o zfcp drives the System z 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.

zSeries in a SAN – Topologies

point-to-point

direct attached
arbitrated loop

switched fabric

supported

NOT
supported

supported

Tape

Tape | Disk | DVD

Tape | Disk | CD

Why FCP?

o Completely new set of IPL I/O devices

- SCSI over Fiber Channel I/O devices
- Different to any traditional z I/O device

o Additional addressing parameters

o Performance

- FCP is much faster than FICON
- Asynchronous I/O
- No ECKD emulation overhead

o No disk size restrictions

o Up to 16 partitions

o Get rid of FICON topology constraints, FCP is much more flexible.

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Why FCP? – cont.

o System z integration in existing FC SANs

o Use of existing FICON infrastructure

- FICON/FICON Express adapter cards
- FC switches
- Cabling
- Storage subsystems

o Dynamic configuration

- Adding of new storage subsystems possible without IOCDS change

o Requires slightly more CPU than FICON

o SAN access control mechanisms only usable with NPIV (z9 only)

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Disk Usage – ECKD and SCSI Comparison
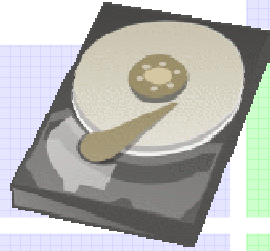
	ECKD DASD	SCSI Disk
Configuration	IOCDS/VM (operator)	IOCDS/VM & Linux (operator & Linux admin)
Access Method	SSCH/CCW	QDIO
Block Size (Byte)	512, 1K, 2K, 4K	512
Disk Size	3390 Model 3/9	any
Formatting (low level)	dasdfmt	not necessary
Partitioning	fdasd	fdisk
File System	mke2fs (or others)	
Access	Mount	

Device Support

o IBM I/O connectivity website
   http://www-03.ibm.com/systems/z/connectivity/products/fc.html

o IBM TotalStorage 3590 Tape Drive
o IBM TotalStorage 3592 Tape Drive
o IBM TotalStorage 3494 Tape Library
o IBM TotalStorage 3584 Tape Library
o IBM TotalStorage DS6000
o IBM TotalStorage DS8000
o Director/Switch Support
   • CISCO MDS 9020, 9120, 9140 Fabric Switch (IBM 2061-420, 020, 040)
   • CISCO MDS 9216 (IBM 2062-D01, D1A, D1H)
   • CISCO MDS 9500 Directors (IBM 2062-D04, D07, E11)
   • CNT (INRANGE) FC/9000 Directors (2042-001, -128, -256)
   • CNT UltraNet Multi-service Director (2042-N16)
   • IBM TotalStorage SAN256N director (2045-N16)
   • IBM Total Storage SAN140M (2027-140)
   • IBM TotalStorage SAN256M (2027-256)
   • …
   • McDATA Intrepid 6064 and 6140 Directors (2032-064, 140)
   • McDATA 3232 (IBM 2031-232)
   • McDATA Sphereon 4500 Fabric Switch (IBM 2031-224)
   • IBM TotalStorage SAN Switch (2109-F32)
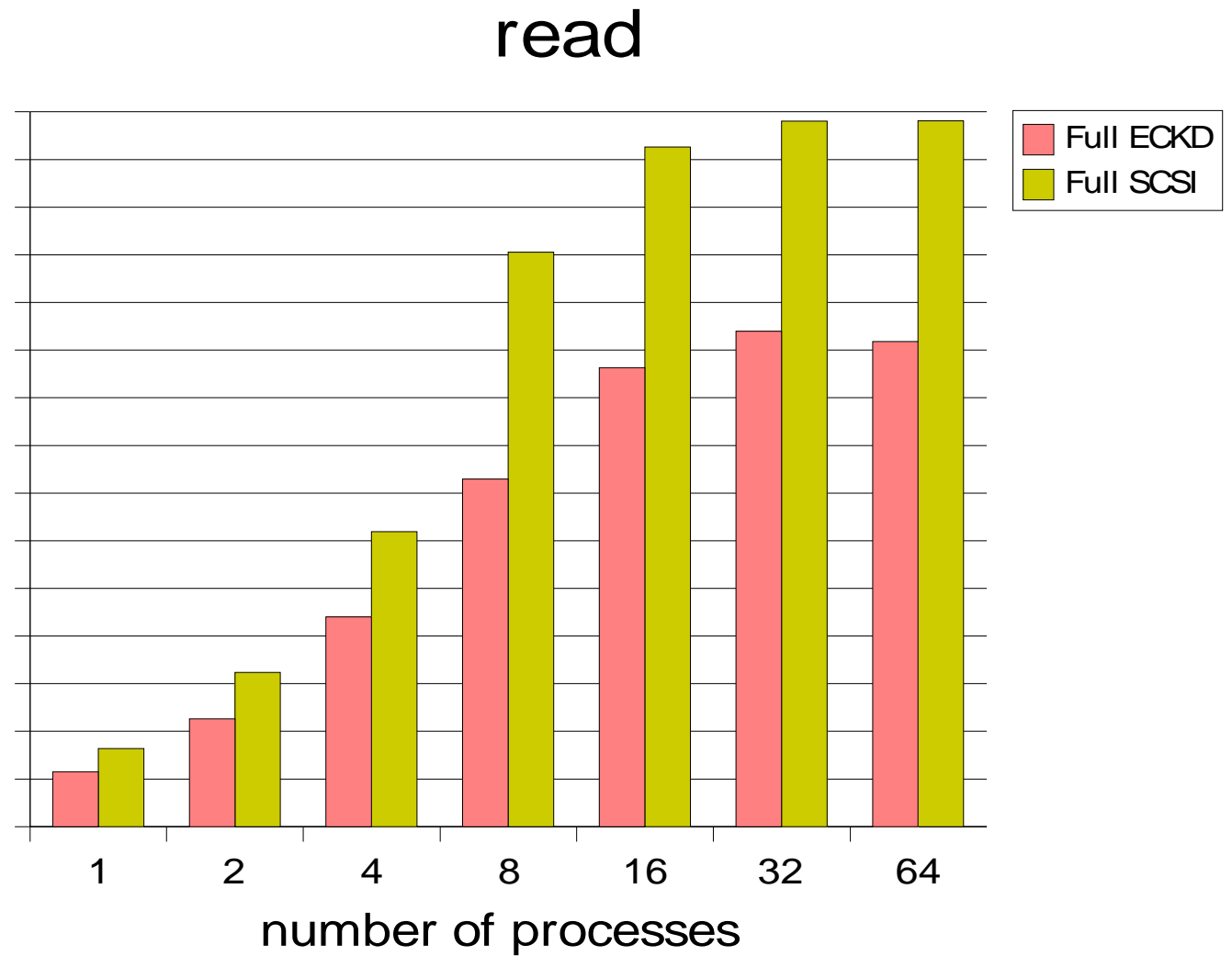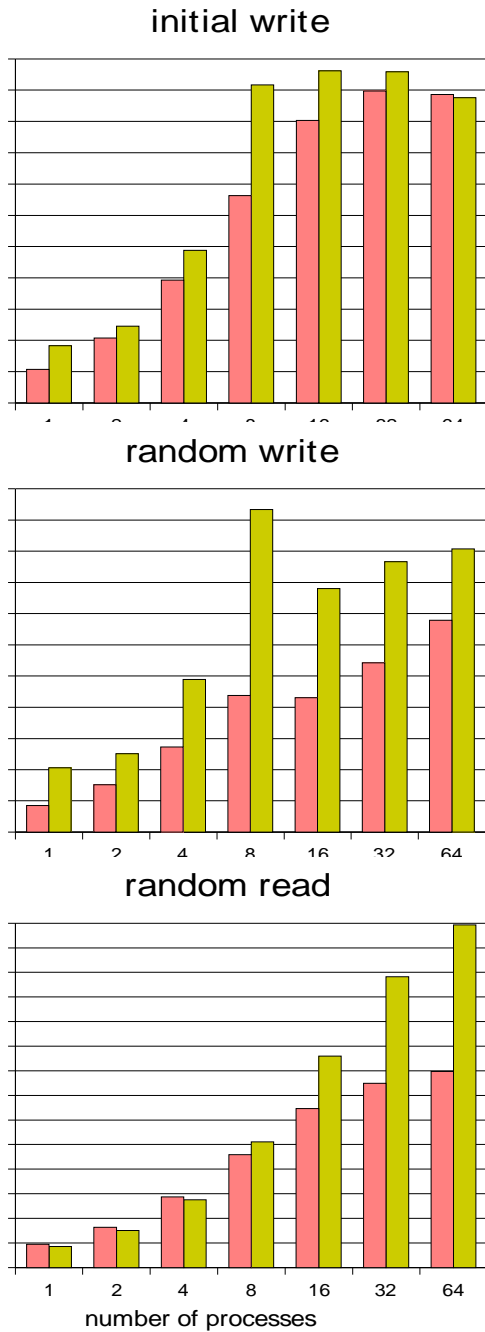   • IBM TotalStorage SAN32B-2 (2005-B32)

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Performance - FCP versus FICON

Throughput for random readers

Legend:
- ECKD LV
- SCSI LV
- ECKD Full
- SCSI Full

x-axis: number of processes (1, 2, 4, 8, 16, 32, 64)
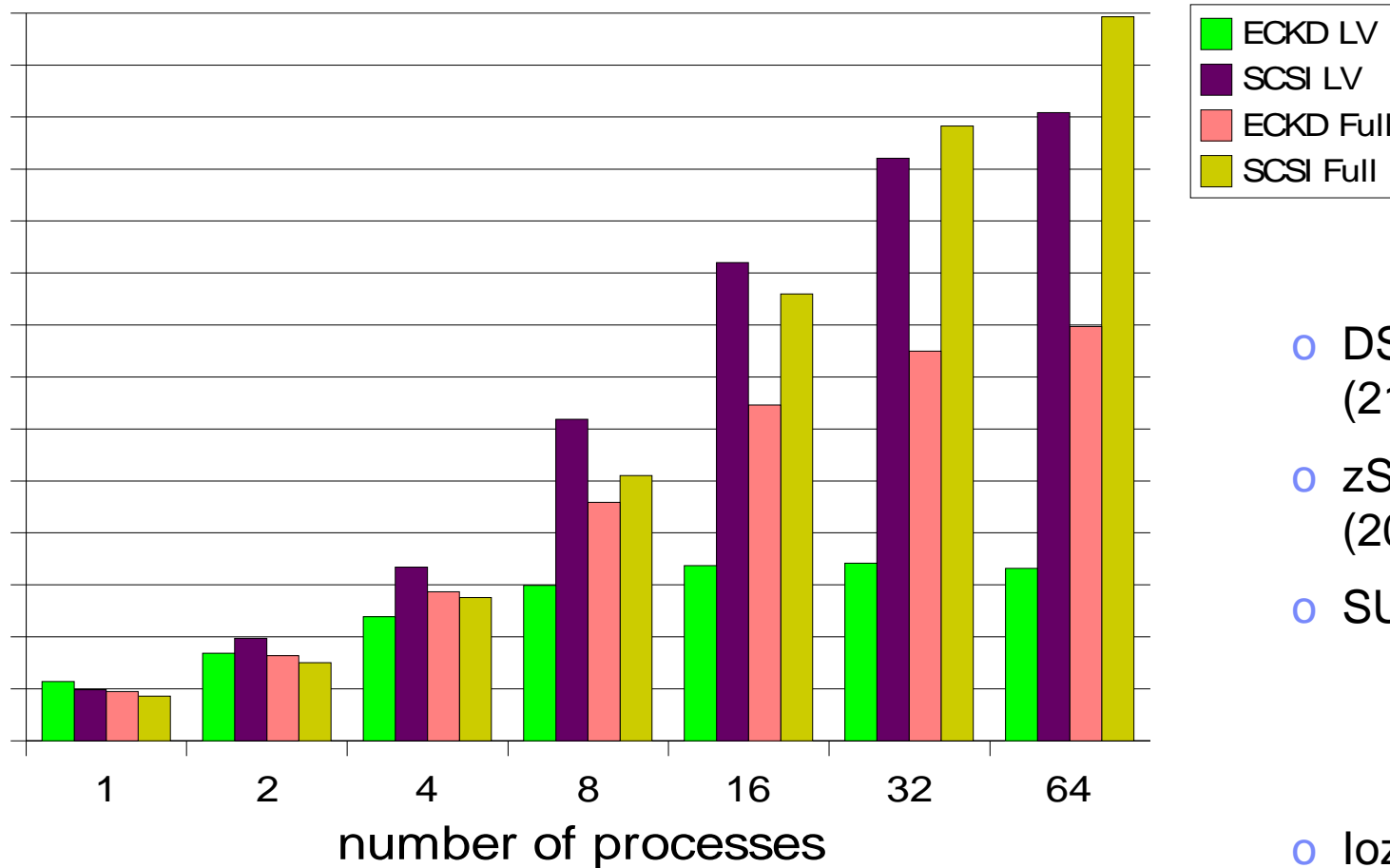
o DS8300 (2107-92E)

o zSeries z990 LPAR (2084-B16)

o SUSE SLES9 SP2
  - 8 CPUs
  - 8 FICON / 8 FCP
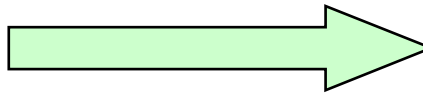 - 256 MB

o Iozone 3.96

FCP Performance - Throughput

initial write

random write

random read

number of processes

read

number of processes

Full ECKD
Full SCSI

FCP – SCSI Mapping

FCP World

SCSI World
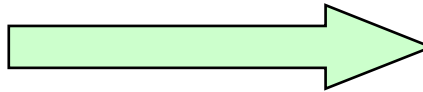
FCP World		SCSI World
HBA	→	Host
0	→	Bus
WWPN	→	SCSI ID
FCP LUN	→	SCSI LUN
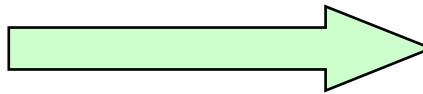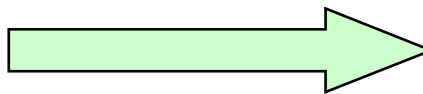
SysFS

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

```
                 ┌─── bus ──────── ccw ──────── drivers ──────── zfcp ──────── 0.0.ddd1
                 │                                                          ├─── 0.0.ddd2
                 │              ccwgroup        devices                     └─── 0.0.ddd3
   /sys ─────────┤                                          dasd-eckd
                 │                                          qeth
                 │
                 └──
```
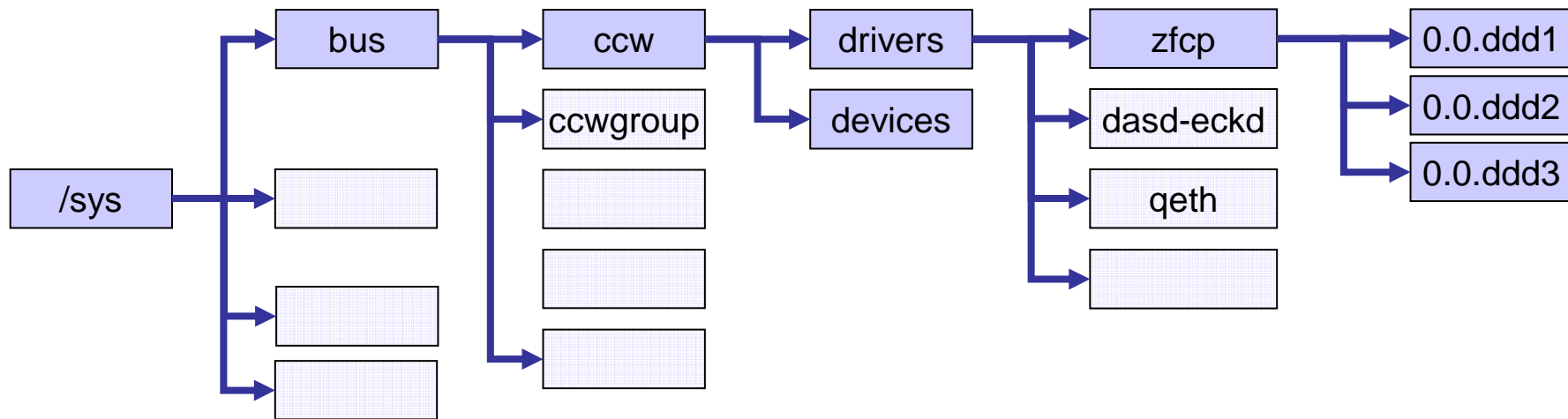
SysFS
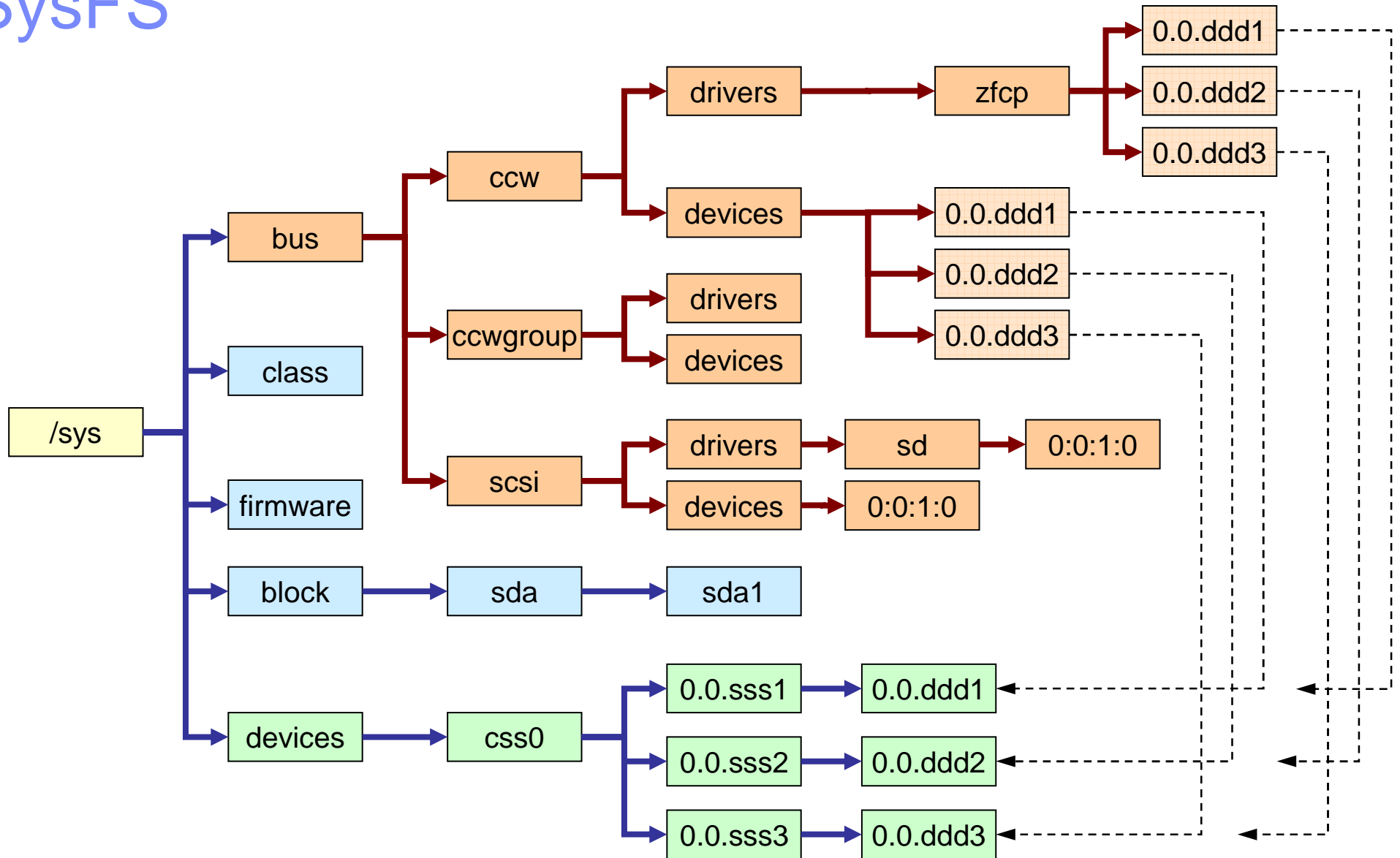
zfcp Configuration

o SUSE: yast
→ hardware
→ zfcp

o Manual zfcp configuration


```
# cd /sys/bus/ccw/drivers/zfcp/0.0.5021/
0.0.5021 # echo 1 > online    OR  0.0.5021 # chccwdev -e 0.0.5021
0.0.5021 # echo 0x500507630303c562 > port_add
0.0.5021 # echo 0x401401600000000 > 0x500507630303c562/unit_add
0.0.5021 #
```
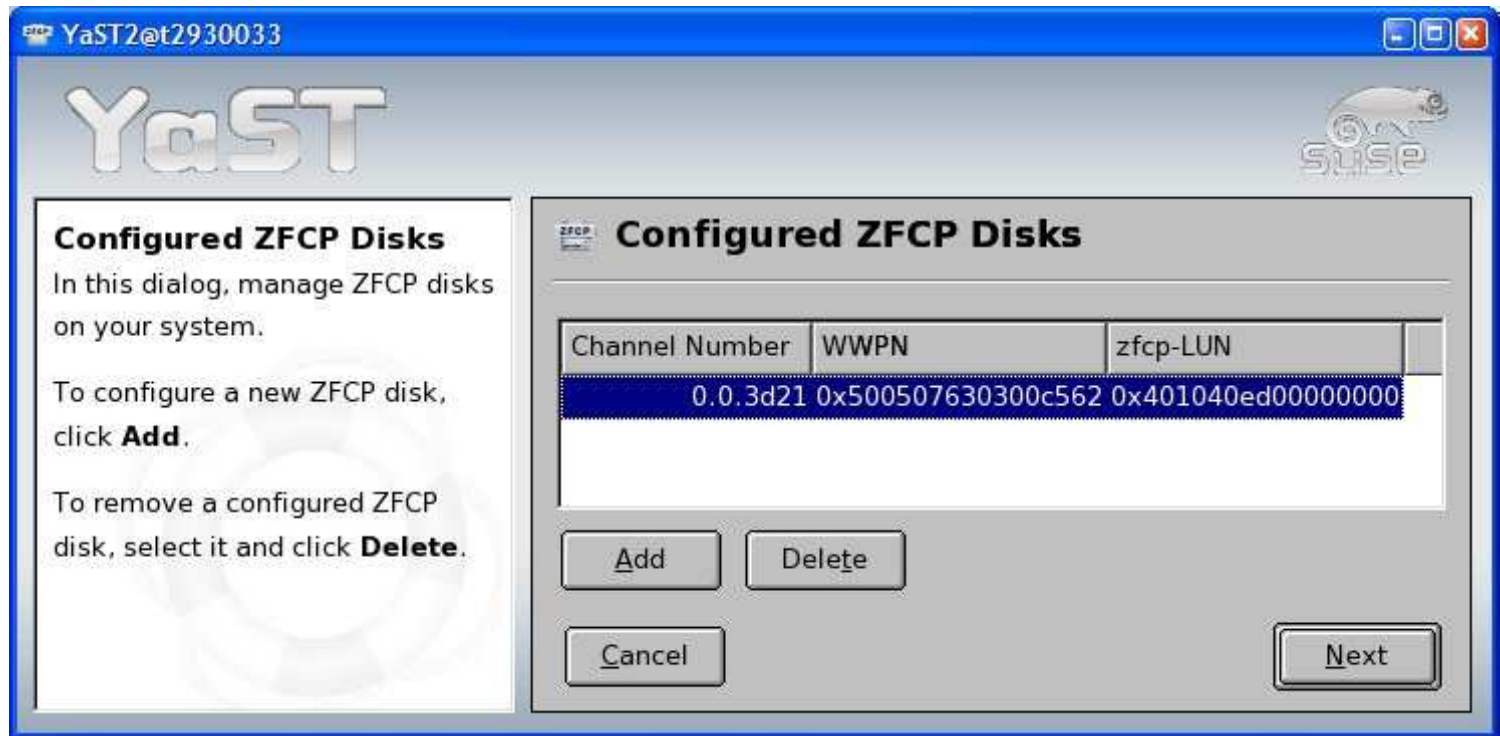
zfcp Configuration – cont.

```
/var/log/messages
Jul 10 03:14:12 t2930033 kernel: scsi1 : zfcp
Jul 10 03:14:12 t2930033 kernel: zfcp: The adapter 0.0.5021 reported the following characteristics:
Jul 10 03:14:12 t2930033 kernel: WWNN 0x5005076400cd6aad, WWPN 0x5005076401008fa8, S_ID 0x00651213,
Jul 10 03:14:12 t2930033 kernel: adapter version 0x3, LIC version 0x605, FC link speed 2 Gb/s
Jul 10 03:14:12 t2930033 kernel: zfcp: Switched fabric fibrechannel network detected at adapter 5021
Jul 10 03:14:42 t2930033 kernel:    Vendor: IBM       Model: 2107900          Rev: .203
Jul 10 03:14:42 t2930033 kernel:    Type:   Direct-Access                     ANSI SCSI revision: 05
Jul 10 03:14:42 t2930033 kernel: SCSI device sdb: 104857600 512-byte hdwr sectors (53687 MB)
Jul 10 03:14:42 t2930033 kernel: SCSI device sdb: drive cache: write back
Jul 10 03:14:42 t2930033 kernel:  sdb: sdb1
Jul 10 03:14:42 t2930033 kernel: Attached scsi disk sdb at scsi1, channel 0, id 1, lun 0
Jul 10 03:14:42 t2930033 kernel: Attached scsi generic sg1 at scsi1, channel 0, id 1, lun 0,  type 0
Jul 10 03:14:42 t2930033 /etc/hotplug/block.agent[4105]: new block device /block/sdb
Jul 10 03:14:42 t2930033 /etc/hotplug/block.agent[4122]: new block device /block/sdb/sdb1
```

```
# lsscsi
[0:0:1:0]    disk    IBM       2107900          .203  /dev/sda
[1:0:1:0]    disk    IBM       2107900          .203  /dev/sdb
# mount /dev/sdb1 /mnt
# df
Filesystem          1K-blocks      Used Available Use% Mounted on
/dev/sda1             5156292   1554996   3339368  32% /
tmpfs                  253272         4    253268   1% /dev/shm
/dev/sdb1            51606124   1629436  47355252   4% /mnt
```

zfcp Configuration – cont.

`/sys/bus/ccw/drivers/zfcp/`

    directory for each subchannel (virtual FCP adapter, e.g. 0.0.5021)

        directory for each configured target port (e.g. 0x500507630303c562)

            directory for each configured FCP LUN (e.g. 0x4011401600000000)

| /sys | → | bus | → | ccw | → | drivers | → | zfcp |

| 0.0.5021 | → | 0x500507630303c562 | → | 0x4011401600000000 | → | attr: failed |

0x500507630303c562	0x4011401600000000	attr: in_recovery
…	…	attr: status
attr: failed	attr: d_id	attr: …
attr: in_recovery	attr: unit-add
attr: status	attr: …
attr: …
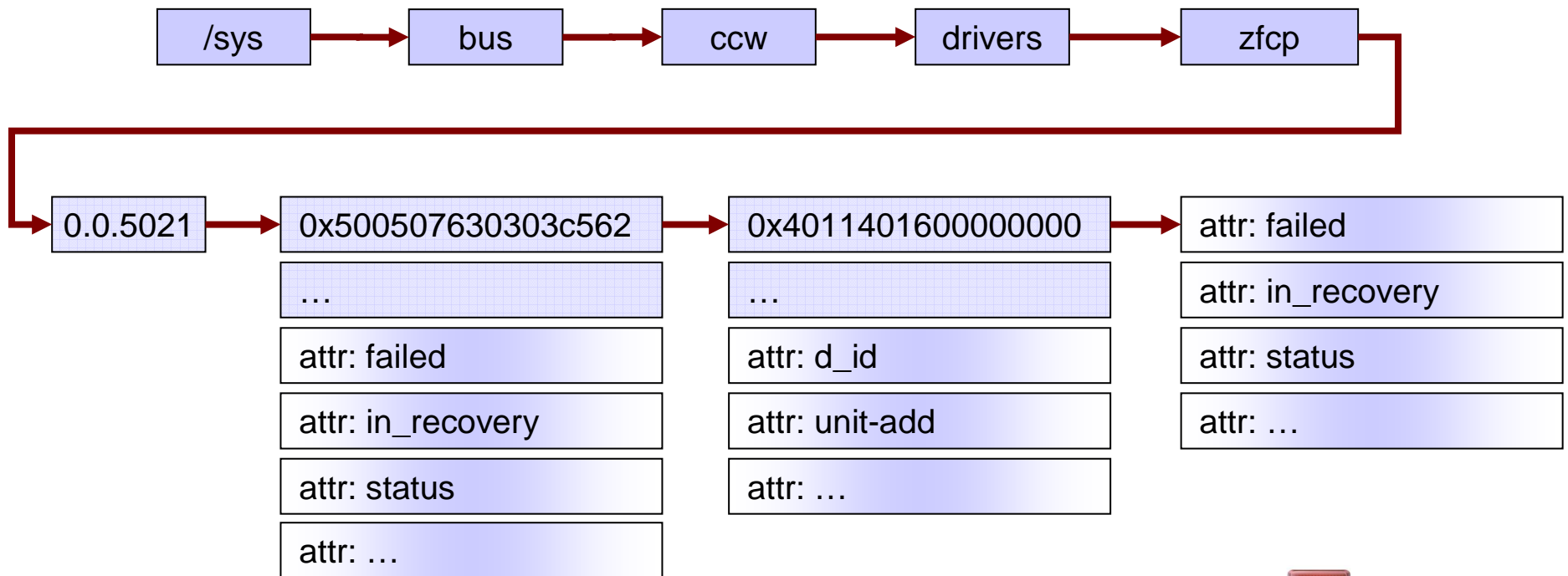
Adapter Information

o **<directory for each configured target port>**

o serial_number   - Adapter serial number

o lic_version   - LIC version number

o scsi_host_no   - SCSI host number

o wwnn   - Worldwide node name

o wwpn   - Worldwide port name

o fc_topology   - Fiber Channel topology

o fc_link_speed   - Link Speed

SLES9

```
# cd /sys/bus/ccw/drivers/zfcp/0.0.3d21/
# cat serial_number
IBM020000000D6AAD
# cat lic_version
0x00000605
# cat scsi_host_no
0x0
```

```
# cat wwnn
0x5005076400cd6aad
# cat wwpn
0x5005076401c08f98
# cat fc_topology
fabric
# cat fc_link_speed
2 Gb/s
```

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Port Information

o <directory for each FCP LUN>

o d_id   - Destination ID

o failed   - Port error recovery status

o in_recovery   - Recovery status

o scsi_id   - SCSI ID

o wwnn   - Worldwide node name

SLES9

```
# cd /sys/bus/ccw/drivers/zfcp/0.0.3d21/0x500507630300c562/
# ls
  0x401040ed00000000 d_id failed scsi_id unit_add wwnn access_denied
  detach_state  in_recovery  status    unit_remove
# cat in_recovery
0
# cat scsi_id
0x1
# cat d_id
0x632e13
```

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Unit Information

o access_*   - Access Control

o failed   - Unit error recovery status

o in_recovery - Recovery status

o scsi_lun   - Linux SCSI LUN

o status   - Unit status (debug info)

SLES9

```
# cd /sys/bus/ccw/drivers/zfcp/0.0.3d21/0x500507630300c562/0x401040ed00000000/
# ls
  access_denied  access_readonly  access_shared  detach_state  failed
  in_recovery  scsi_lun  status
# cat failed
0
# cat in_recovery
0
# cat scsi_lun
0x0
# cat status
0x54000000
```
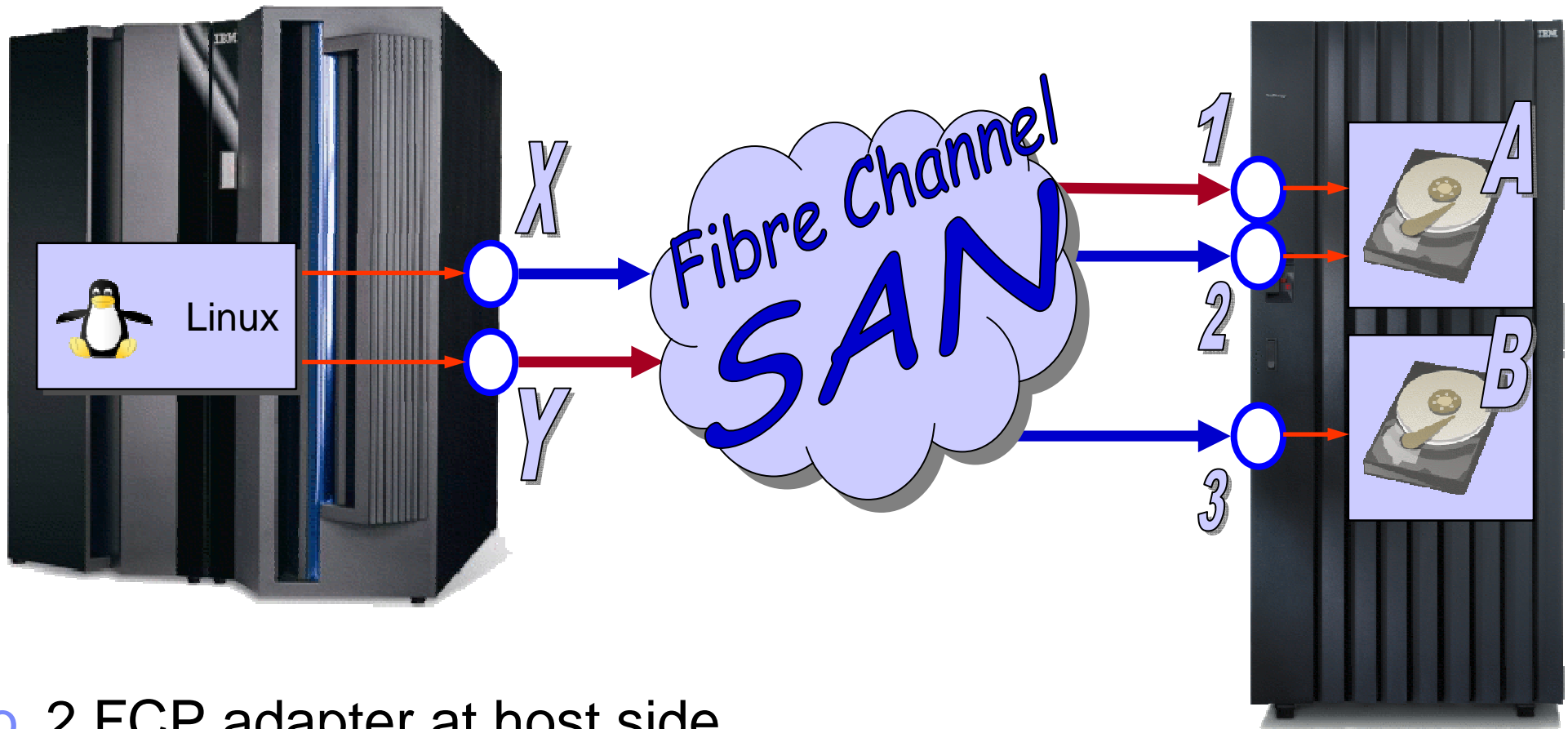
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FCP Multipathing

o "Failover" on path-failure and "failback"

o Load balancing

o Covers all block devices

o LVM – Logical Volume Manager

o Device Mapper subsystem in 2.6 kernel

- EVMS – Enterprise Volume Management System

- LVM2 – Logical Volume Manager 2

- MP-Tools – Multipath-Tools

o MD – Multiple devices
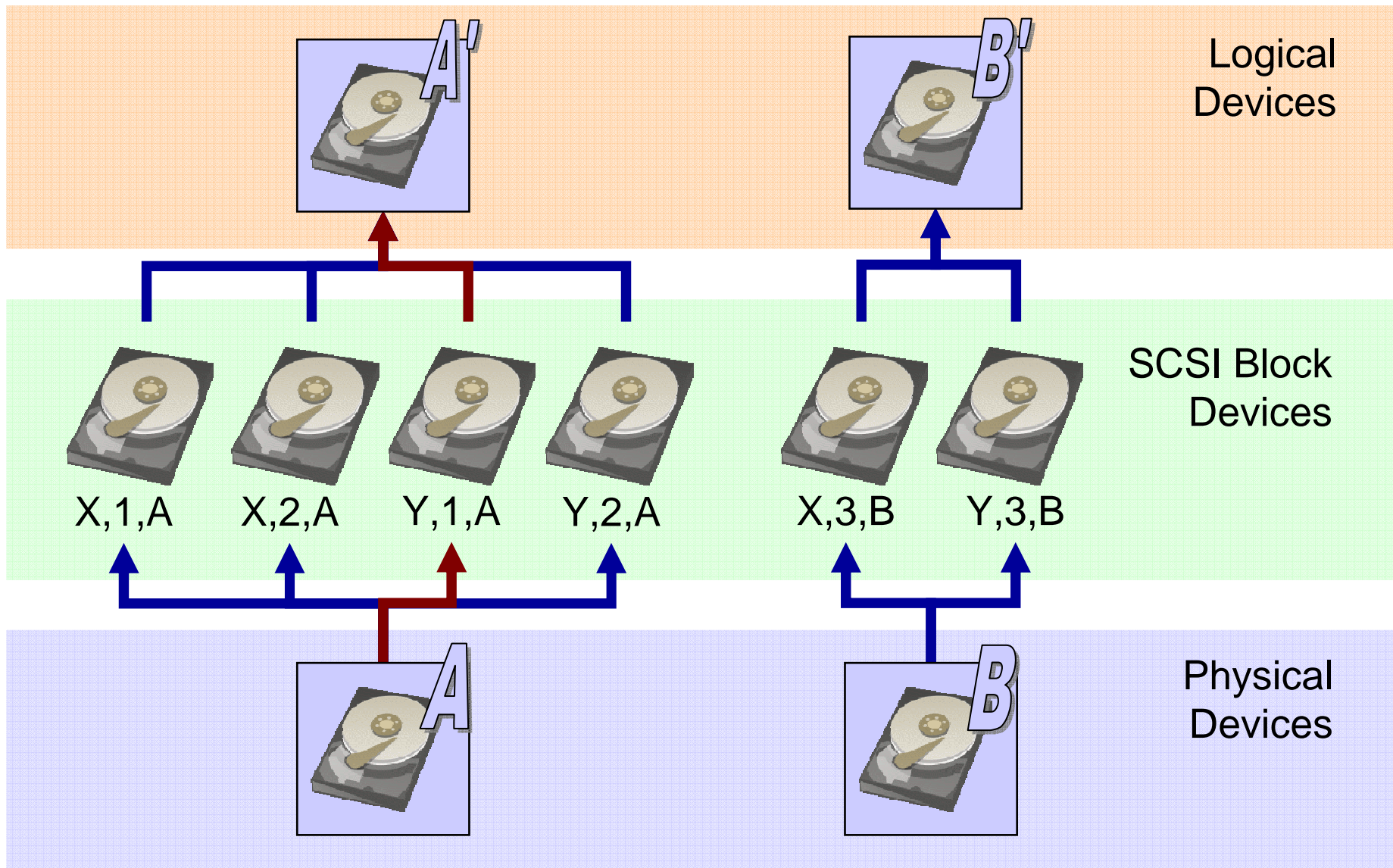
FCP Multipathing

o 2 FCP adapter at host side

o 3 FCP adapter at storage side

o 4 paths to disk A and 2 paths to disk B

FCP Multipathing – Devices

Multipath-Tools Package

```
# multipath -l
mpath0 (36005076303ffc56200000000000010ed)
[size=5 GB][features="1
   queue_if_no_path"][hwhandler="0"]
\_ round-robin 0 [active]
 \_ 0:0:1:0      sda    8:0    [active]
 \_ 1:0:1:0      sdb    8:16   [active]
 \_ 0:0:2:0      sdc    8:32   [active]
 \_ 1:0:2:0      sdd    8:48   [active]


mpath1 (IBM.75000000092461.2a00.1a)
[size=2 GB][features="0"][hwhandler="0"]
\_ round-robin 0 [active]
 \_ 0:0:10778:0 dasdd 94:12 [active]
 \_ 0:0:10927:0 dasde 94:16 [active]
 \_ 0:0:10928:0 dasdf 94:20 [active]
 \_ 0:0:10929:0 dasdg 94:24 [active]


# ls -l /dev/mapper/
total 0
crw-------  1 root root  10, 63 Jun 27 09:11 control
brw-rw----  1 root disk 253,  4 Jun 28 07:51 mpath0
brw-rw----  1 root disk 253,  5 Jun 28 07:51 mpath0p1
brw-rw----  1 root disk 253,  0 Jun 27 10:05 mpath1
brw-rw---   1 root disk 253,  3 Jun 27 10:05 mpath1p1
```

o Developed by Christophe Varoqui

o Link: http://christophe.varoqui.free.fr/wiki/wakka.php?wiki=Home

o RedHat: device-mapper-multipath

o SUSE: multipath-tools

o Development ongoing

MP-Tools

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SAN Discovery Tool

o Identification of SAN resources

- List of host adapters, ports, units

o Helpful to uncover configuration problems

- E.g. zoning or LUN masking problems

o Does not configure zfcp automatically

```
# san_disc -c PORT_LIST -a 1
 #  Port WWN              Node WWN             DID       Type
  1 0x500507640140863c 0x5005076400cd6aad 0x650613 N_Port
  2 0x50050764010087ef 0x5005076400cd6aad 0x650713 N_Port
    ...
 97 0x500507640140863c 0x5005076400cd6abd 0x650613 N_Port
```
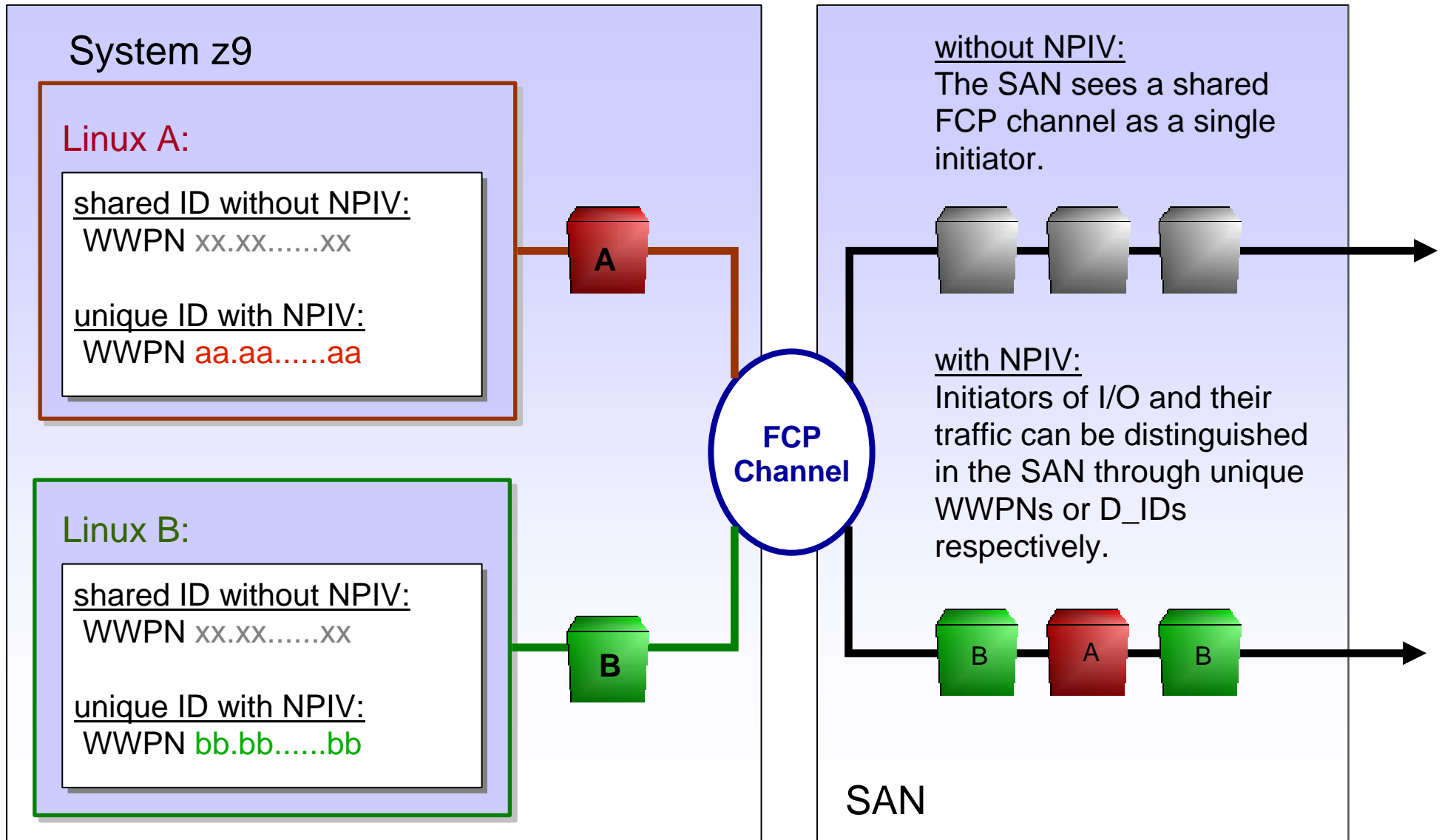
Port list

```
# san_disc -c REPORT_LUNS -a 1 -p 0x500507640140863c
Number of LUNs: 97
#    LUN
  1 0x4010400000000000
  2 0x4010400100000000
    ...
 97 0x4010406000000000
```

LUN list

　Session 9259

NPIV – N-Port ID Virtualization

Unique SAN Identities!

System z9

Linux A:

shared ID without NPIV:
 WWPN xx.xx......xx

unique ID with NPIV:
 WWPN aa.aa......aa

A

Linux B:

shared ID without NPIV:
 WWPN xx.xx......xx

unique ID with NPIV:
 WWPN bb.bb......bb

B

FCP Channel

without NPIV:
The SAN sees a shared FCP channel as a single initiator.

with NPIV:
Initiators of I/O and their traffic can be distinguished in the SAN through unique WWPNs or D_IDs respectively.

B   A   B

SAN

SCSI IPL & SCSI Dump

Load

CPC: P000F12B

Image: ZFCP4

Load type: ○ Normal ○ Clear ● SCSI ○ SCSI dump

☐ Store status

Load address	5C00
Load parameter	
Time-out value	060 60 to 600 seconds
World wide port name	5005076300CE93A7
Logical unit number	5732000000000000
Boot program selector	0
Boot record logical block address	0000000000000000
OS specific load parameters	

OK   Reset   Cancel   Help

o IPL from SCSI disks
o Dump to SCSI disks (LPAR only).

o SCSI disks expand the set of IPL'able devices
o SCSI disks as Linux root file system possible

o New set of IPL parameters.
o LPAR and z/VM guests supported.

Requirements

o z800, z890, z900, z990, z9

o Requires enablement by FC9904

o FCP Channels

o FC attached SCSI Disks

zSeries

SCSI IPL

SCSI IPL – example z/VM

```
Ready; T=0.01/0.01 22:09:48
set loaddev port 50050763 0300C562 lun 401040EE 00000000
Ready; T=0.01/0.01 22:11:01

query loaddev
PORTNAME 50050763 0300C562    LUN  401040EE 00000000    BOOTPROG 0
BR_LBA    00000000 00000000
Ready; T=0.01/0.01 22:11:06


i 5021
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.
00: MLOEVL012I: Machine loader up and running (version 0.18).
00: MLOPDM003I: Machine loader finished, moving data to final storage location.
Linux version 2.6.16-18.x.20060403-s390xdefault (wirbser@t2944002) (gcc version
4.1.0) #1 SMP PREEMPT Mon Apr 3 09:56:54 CEST 2006
We are running under VM (64 bit mode)
Detected 4 CPU's
Boot cpu address  0
Built 1 zonelists
Kernel command line: dasd=e960-e962 root=/dev/sda1 ro noinitrd
   zfcp.device=0.0.3d21,0x500507630300c562,0x401040ee00000000
```

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Summary

o FCP/SCSI support for IBM System z.

- FCP channel based on FICON / FICON Express adapter cards.
- FCP channel support in z/VM 4.3 and higher for Linux guests.
- First FCP/SCSI exploitation for System z in SLES8 and RHEL3.

o Integration of your zSeries into standard based FC SANs.

o New device types.

o Three addressing parameters instead of one

o Performance and other advantages compared to ECKD

o Without NPIV: No LUN sharing or zoning on a single adapter → use separate physical adapters

o With NPIV: SAN access control mechanisms (z9 only)

o Helpful SAN Discovery Tool

Useful Links

o I/O Connectivity on IBM zSeries mainframe servers
- http://www-03.ibm.com/systems/z/connectivity/

o Getting Started with zSeries Fiber Channel Protocol, IBM Redpaper
- http://www.redbooks.ibm.com/redpapers/pdfs/redp0205.pdf

o z/VM
- Version 5.2: http://www.vm.ibm.com/zvm520/

o Introducing N_Port Identifier Virtualization for IBM System z9 (Redpaper)
- http://www.redbooks.ibm.com/redpapers/pdfs/redp4125.pdf

o How to use FC-attached SCSI devices with Linux on System z
- http://download.boulder.ibm.com/ibmdl/pub/software/dw/linux390/docu/l26cts00.pdf

o Linux for IBM System z
- http://www-128.ibm.com/developerworks/linux/linux390/

o Linux for IBM System z Device Drivers Book and other documentation
- http://www-128.ibm.com/developerworks/linux/linux390/april2004_documentation.html (SLES9)
- http://www-128.ibm.com/developerworks/linux/linux390/october2005_documentation.html (SLES10)

o IBM TotalStorage Tape Device Drivers – Installation and User's Guide
- ftp://ftp.software.ibm.com/storage/devdrvr/Doc/

o IBM disk systems
- http://www-03.ibm.com/servers/storage/disk/

o linuxvm.org
- http://www.linuxvm.org/

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