Making Your Penguins Fly

Introduction to SCSI over FCP

for Linux on System z

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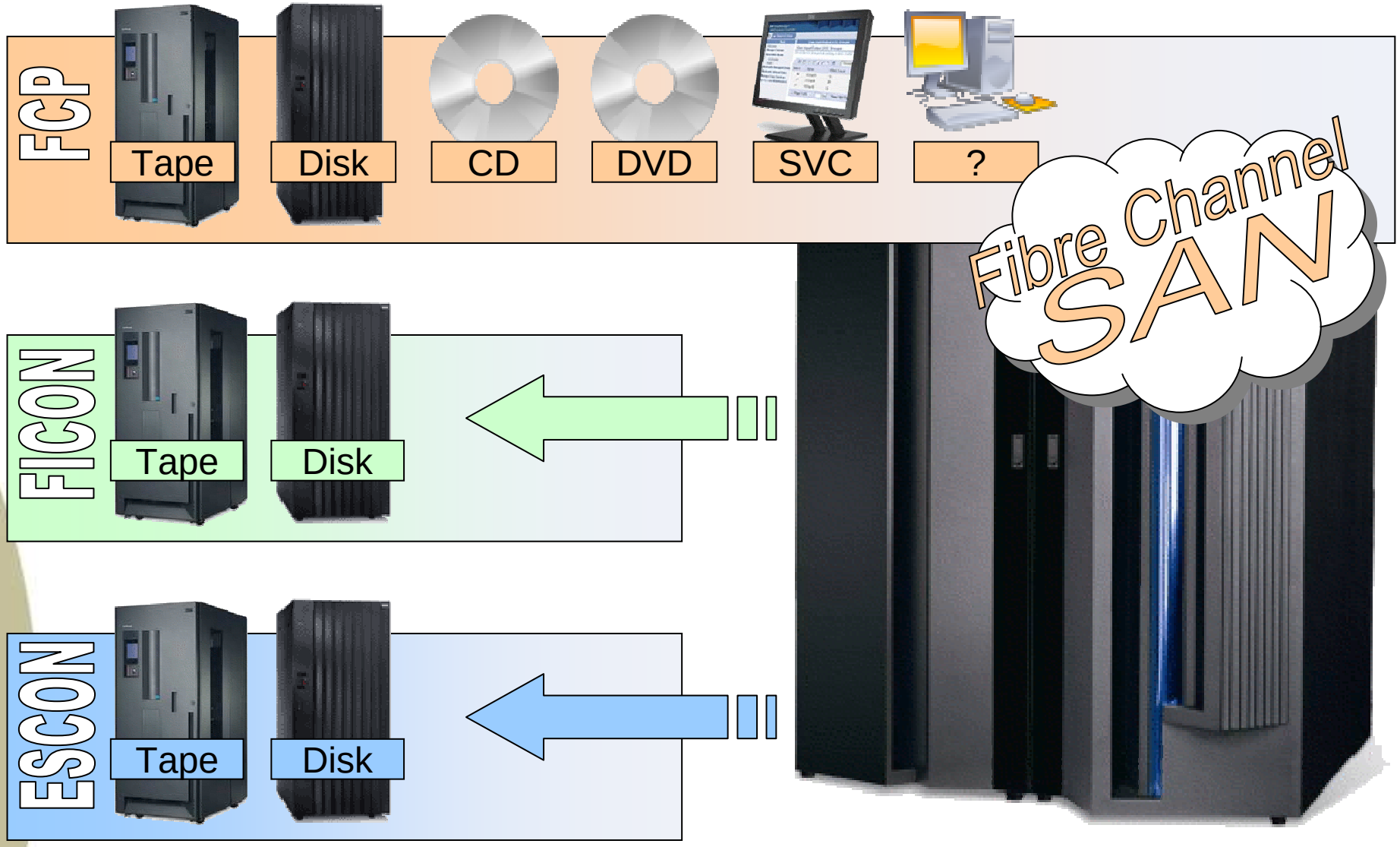
February 27th 2008
Session 9259

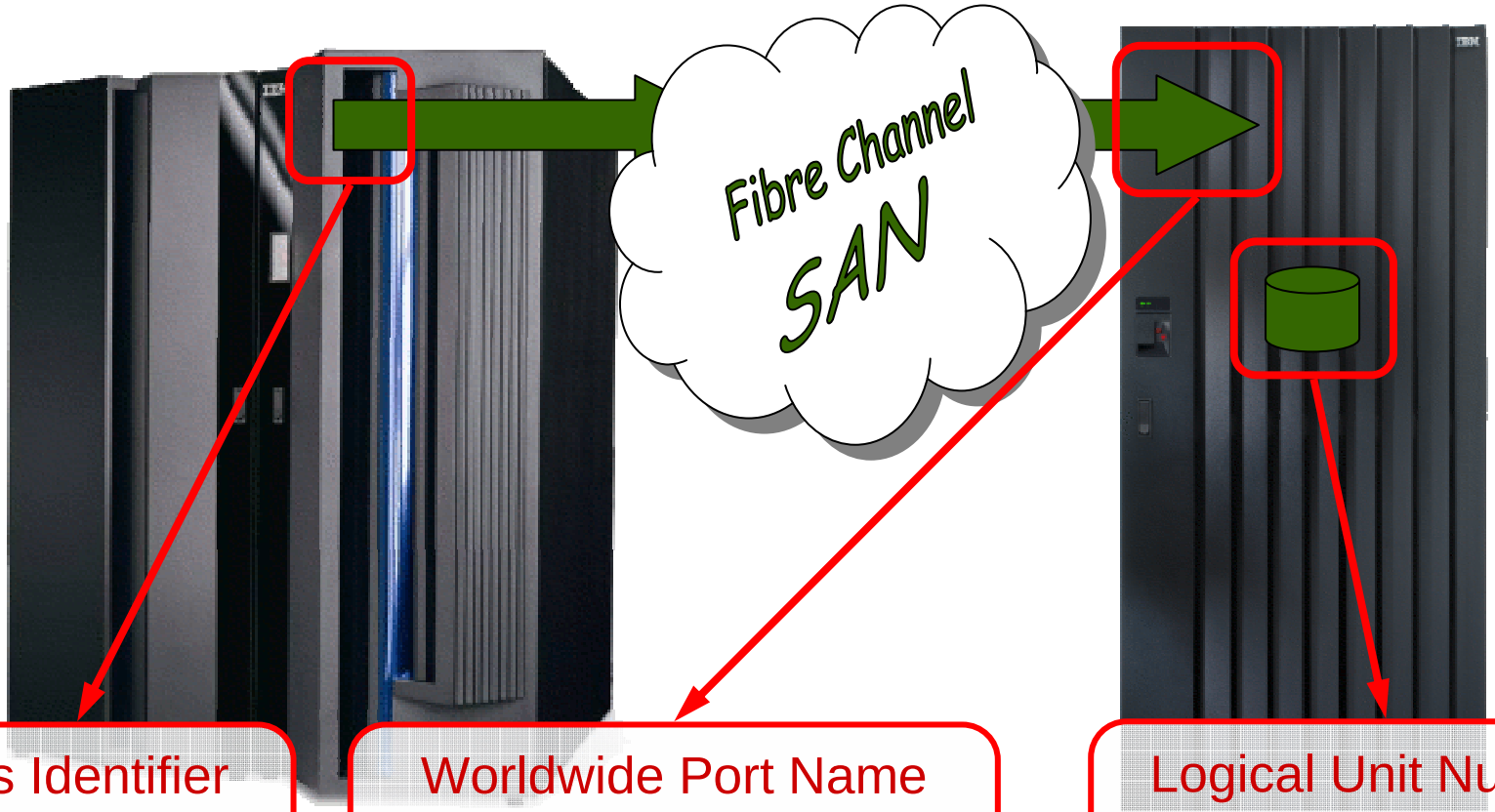
Making Your Penguins Fly – Flight Schedule

- SAN & SAN integration
- Addressing basics
- Requirements
- zfcp device driver
- Why FCP?
- Configuration
- Multipathing
- SCSI tape
- SAN Discovery Tool
- NPIV
- SCSI IPL/Dump

System z in a SAN – Sharing Storage Resources



Navigating in a SAN

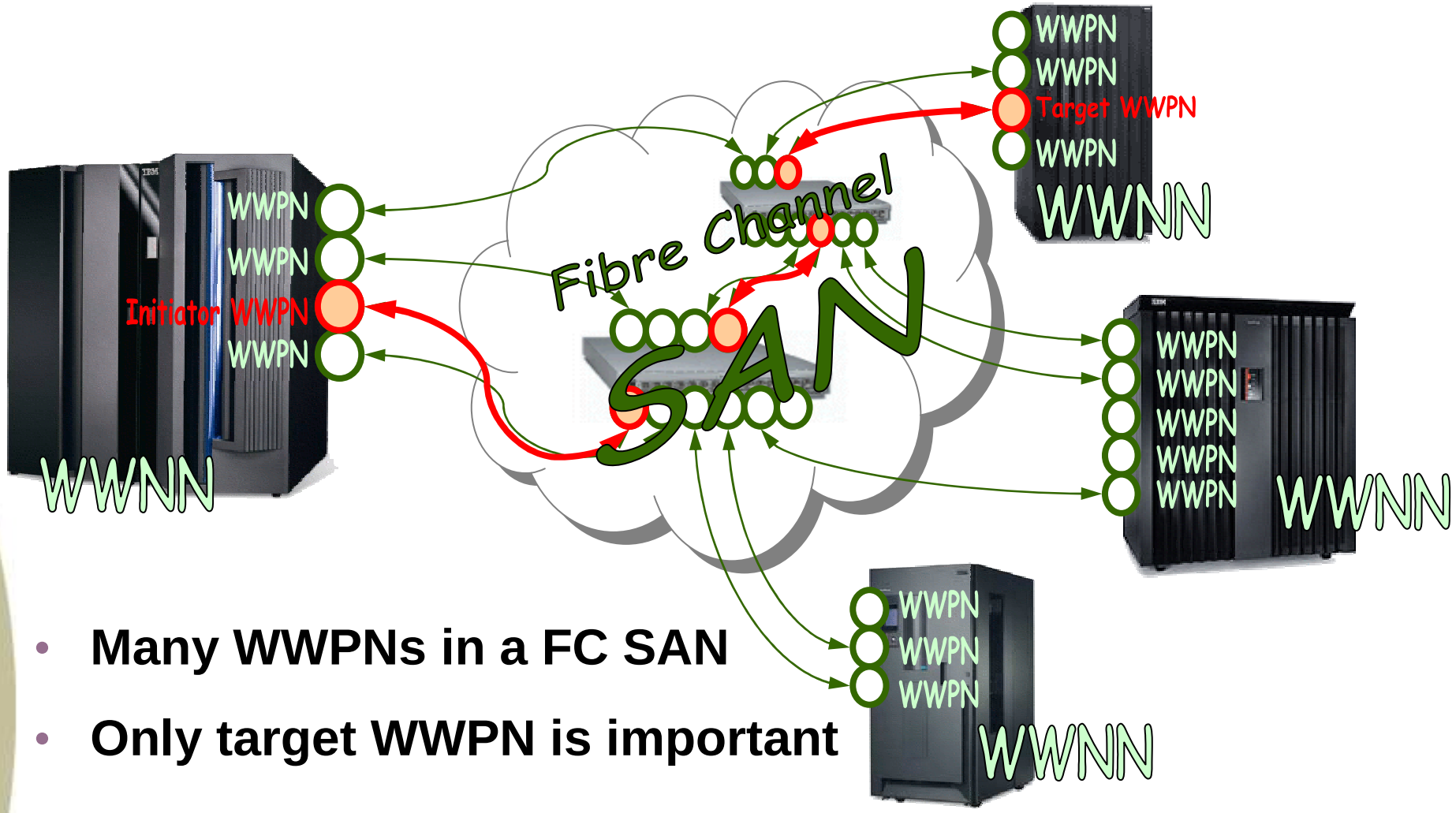


Bus Identifier
(busid)
e.g. 0.0.e962

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

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

WWPNs and other Ports



- **Many WWPNs in a FC SAN**
- **Only target WWPN is important**

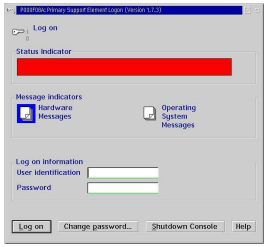
System z in a SAN – Hardware Requirements

- **IBM zSeries 800, 890, 900 or 990**
  IBM System z9 EC/BC
  (NPIV z9-only)
- **FICON or FICON Express adapter cards**
- **CHPID type FCP**
- **FC fabric switch**
- **FC storage subsystem**
- **Optional: FCP-SCSI bridge + SCSI devices**

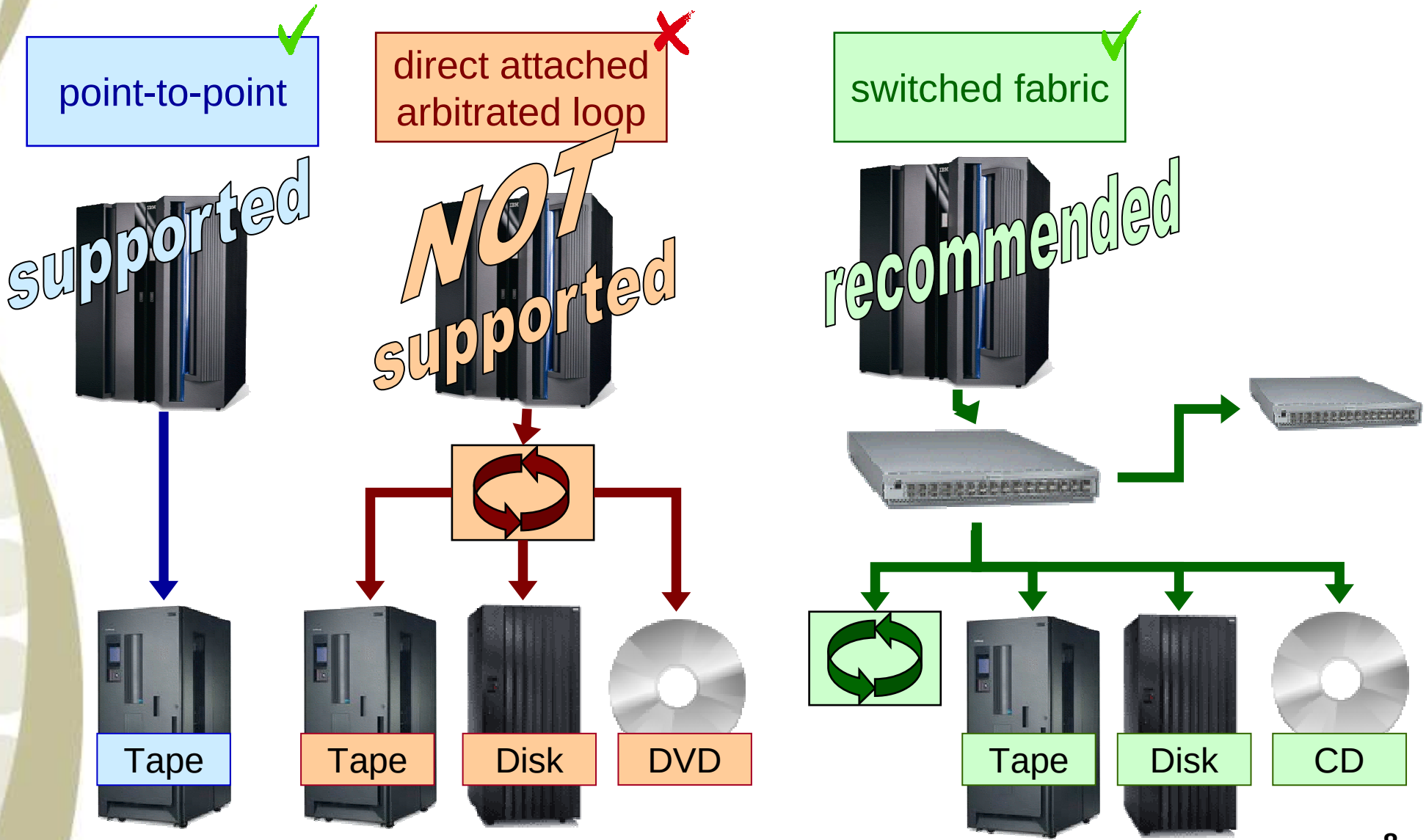
IOCDS – FCP Configuration Sample

```
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
```



System z in a SAN – Topologies



Device Support

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

- **IBM TotalStorage 3590 Tape Drive**
- **IBM TotalStorage 3592 Tape Drive**
- **IBM TotalStorage 3494 Tape Library**
- **IBM TotalStorage 3584 Tape Library**
- **IBM TotalStorage DS6000**
- **IBM TotalStorage DS8000**
- **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)**
  - **…**

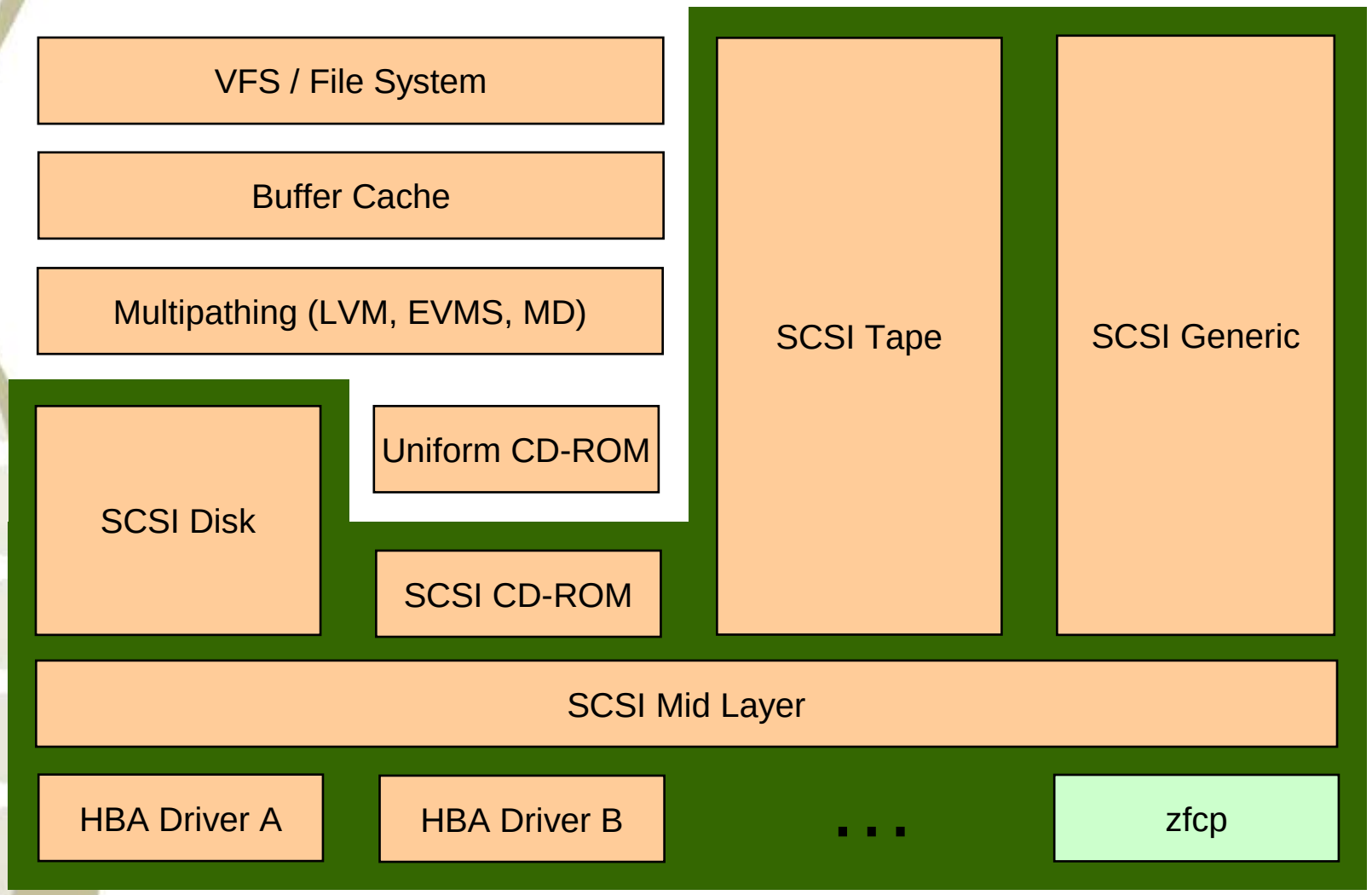
Software Requirements

- **SCSI (IPL) with z/VM**
  - **z/VM Version 4.4 (PTF UM30989) or newer**
  - **z/VM Version 5.3 (current version)**

- **SLES9 - SUSE Linux Enterprise Server 9 (GA 08/2004)**
  - **Kernel 2.6.5, GCC 3.3.3**
  - **Service Pack 3 (GA 12/2005)**
- **SLES10 - SUSE Linux Enterprise Server 10 (GA 07/2006)**
  - **Kernel 2.6.16, GCC 4.1.0**
  - **Service Pack 1 (GA 06/2007)**

- **RHEL4 - Red Hat Enterprise Linux AS 4 (GA 02/2005)**
  - **Kernel 2.6.9, GCC 3.4.3**
  - **Update 5 (GA 05/2007)**
- **RHEL5 - Red Hat Enterprise Linux AS 5 (GA 03/2007)**
  - **Kernel 2.6.18, GCC 4.1.0**
  - **Available**

Linux SCSI Stack

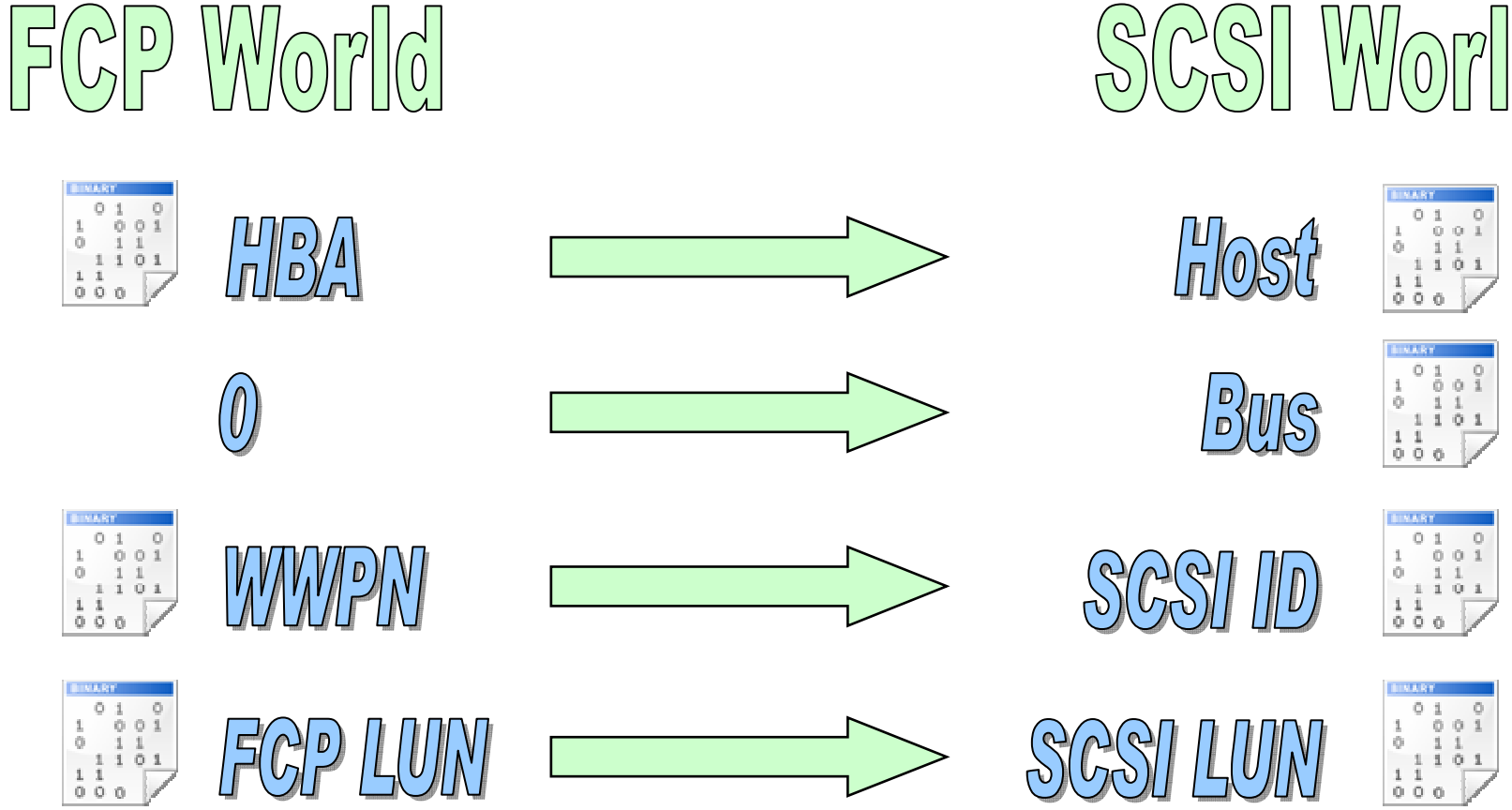


SCSI Stack

zfcp's Task in the Linux SCSI Stack

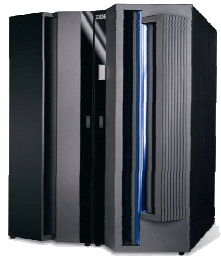
- **zfcp drives the System z FCP host bus adapter.**
  - **maintains connections through the SAN to SCSI devices attached via a System z FCP adapter.**
  - **maps SAN devices to SCSI devices as seen by the Linux SCSI subsystem.**
  - **sends SCSI commands and associated data on behalf of the Linux SCSI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

FCP – SCSI Mapping



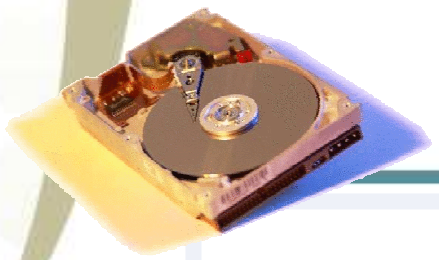
Why FCP?

- **Completely new set of IPL I/O devices**
  - **SCSI over Fiber Channel I/O devices**
  - **Different to any traditional z I/O device**
- **Additional addressing parameters**
- **Performance advantages**
  - **FCP is much faster than FICON**
  - **Reason 1: asynchronous I/O**
  - **Reason 2: no ECKD emulation overhead**
- **No disk size restrictions**
- **Up to 15 partitions (16 minor numbers per device)**
- **SCSI disks do not waste disk space (no low-level formatting)**



Why FCP? – cont.

- System z integration in existing FC SANs
- Use of existing FICON infrastructure
  - FICON/FICON Express adapter cards
  - FC switches / Cabling
  - Storage subsystems
- Dynamic configuration
  - Adding of new storage subsystems possible without IOCDS change
- Does NOT require more CPU than FICON
- SAN access control mechanisms using NPIV (z9 only)
- Get rid of FICON topology constraints, FCP is much more flexible.



ECKD and SCSI Comparison

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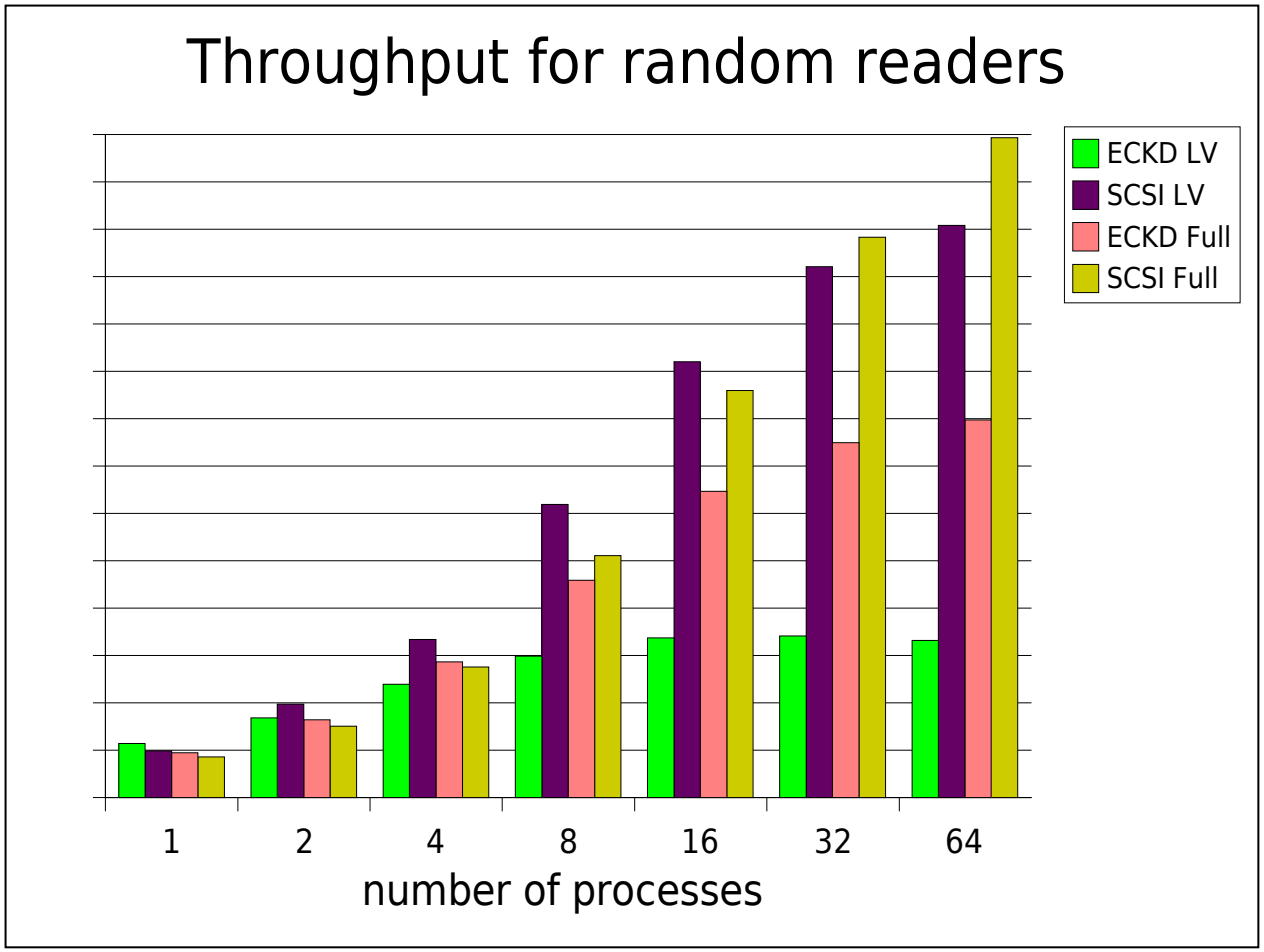
Technology · Connections · Results

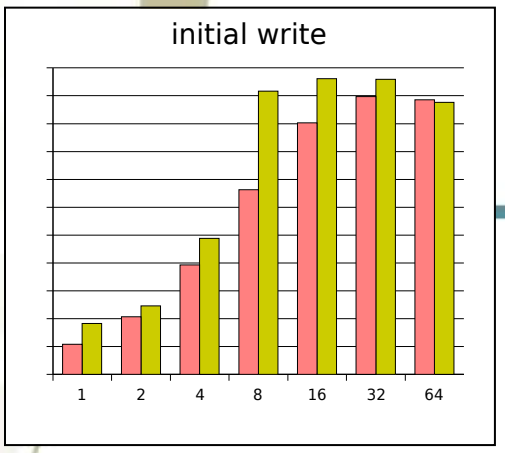
	ECKD DASD	SCSI Disk
Configuration	IOCDS/VM (operator)	IOCDS/VM & SAN & Linux (operator & SAN admin & Linux admin)
Access Method	SSCH/CCW	QDIO
Block Size (Byte)	512, 1K, 2K, 4K	512
Disk Size	3390 Model 3/9	any
Formatting (low level)	dasdfmt	not necessary
Partitioning	fdasd	fdisk
File System	mke2fs (or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

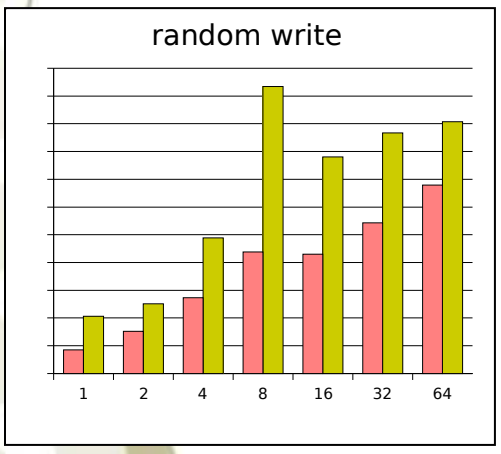
Performance - FCP versus FICON

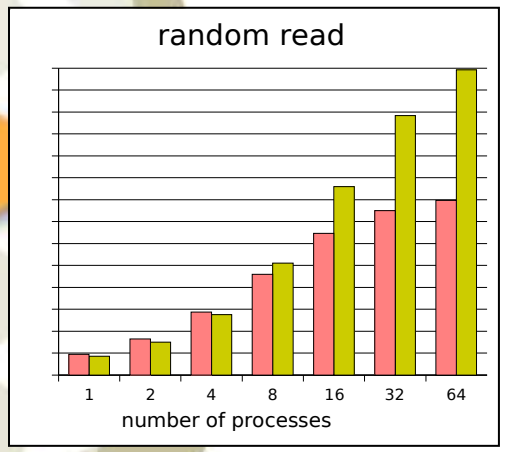


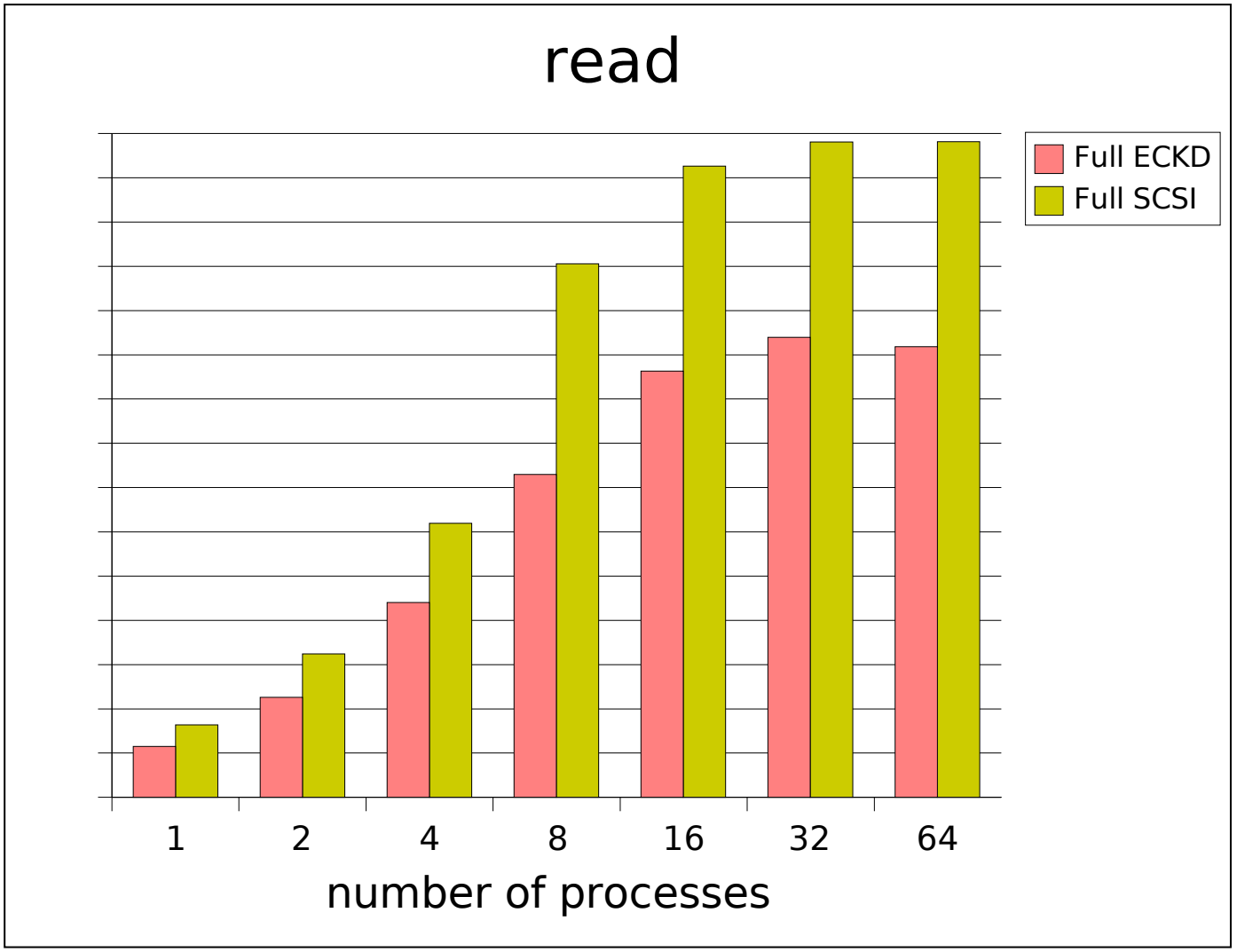
- **DS8300 (2107-92E)**
- **z990 LPAR (2084-B16)**
- **SUSE SLES9 SP2**
  - **8 CPUs**
  - **8 FICON / 8 FCP**
  - **256 MB**
- **Iozone 3.96**

FCP Performance - Throughput









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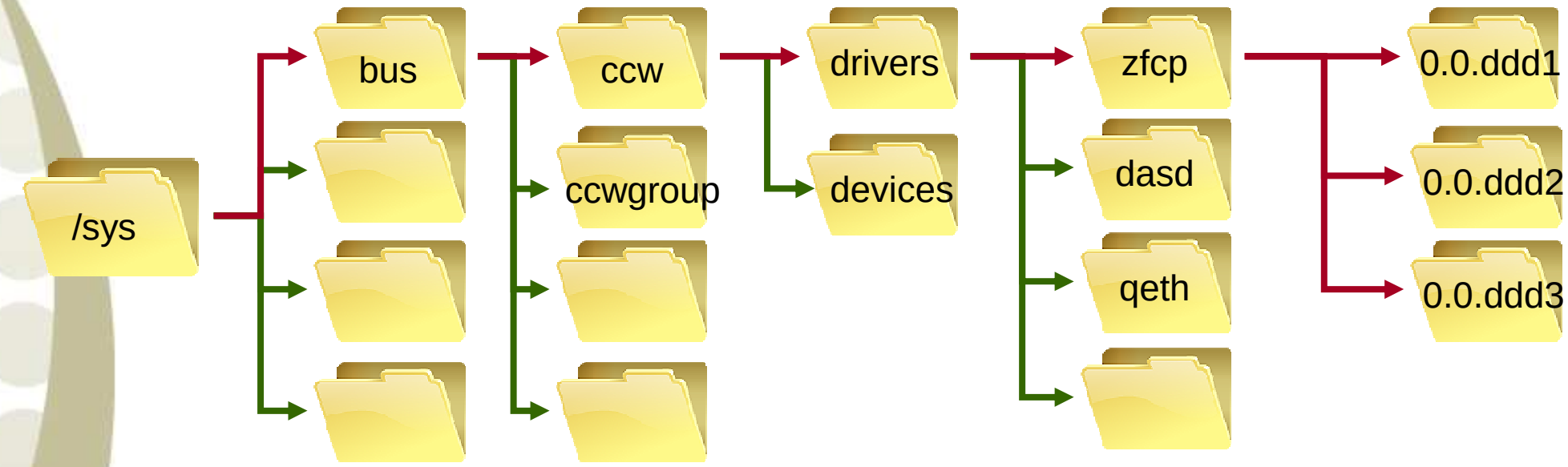
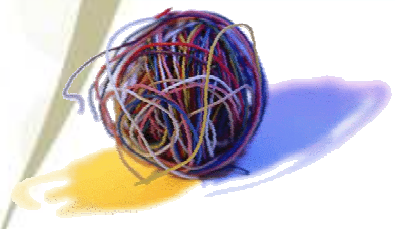
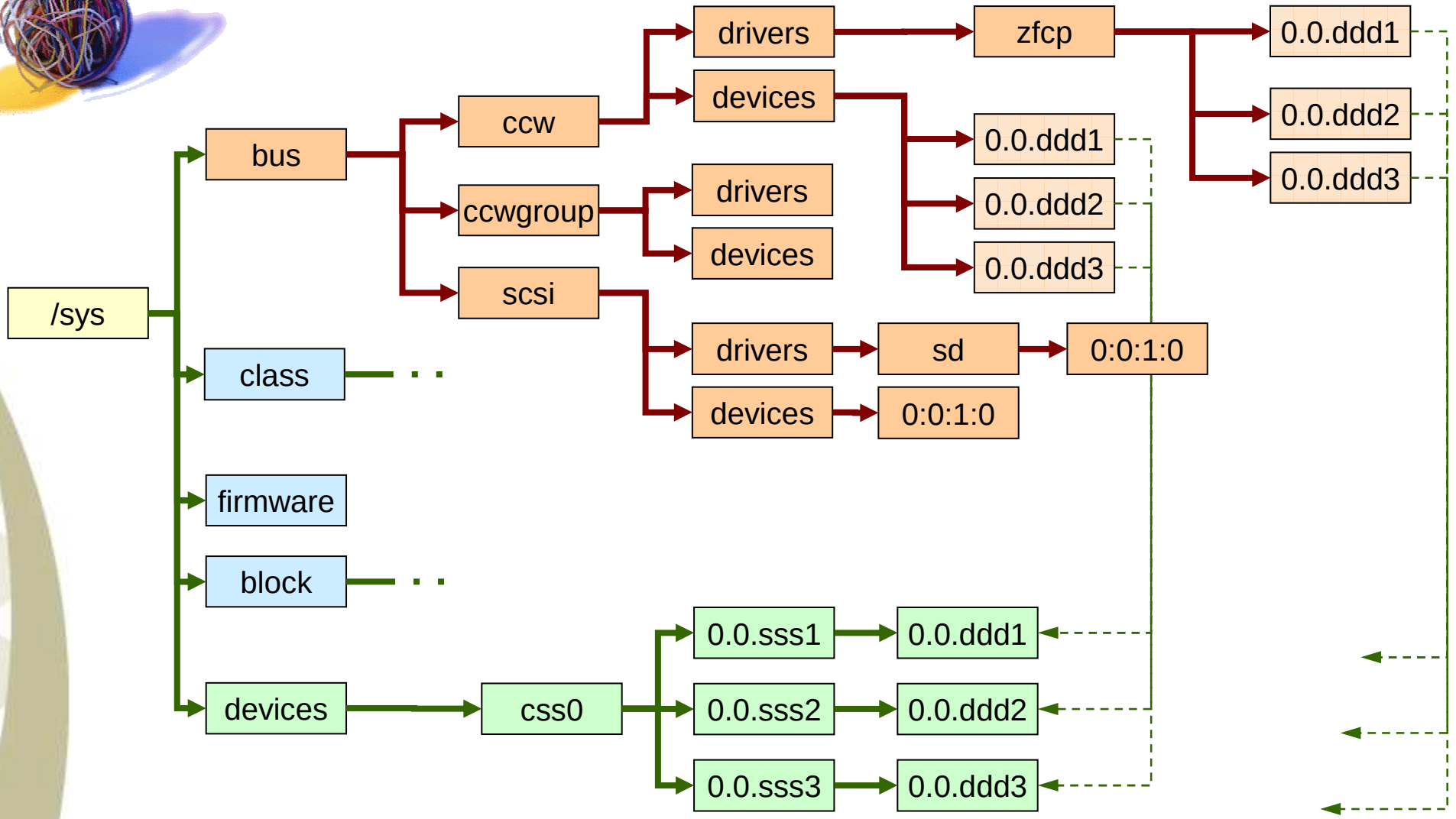
SysFS

- **Configuration file system (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**

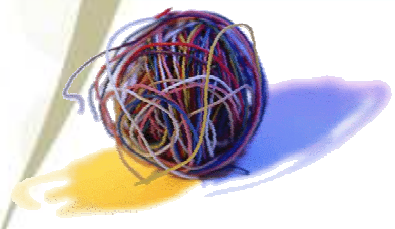


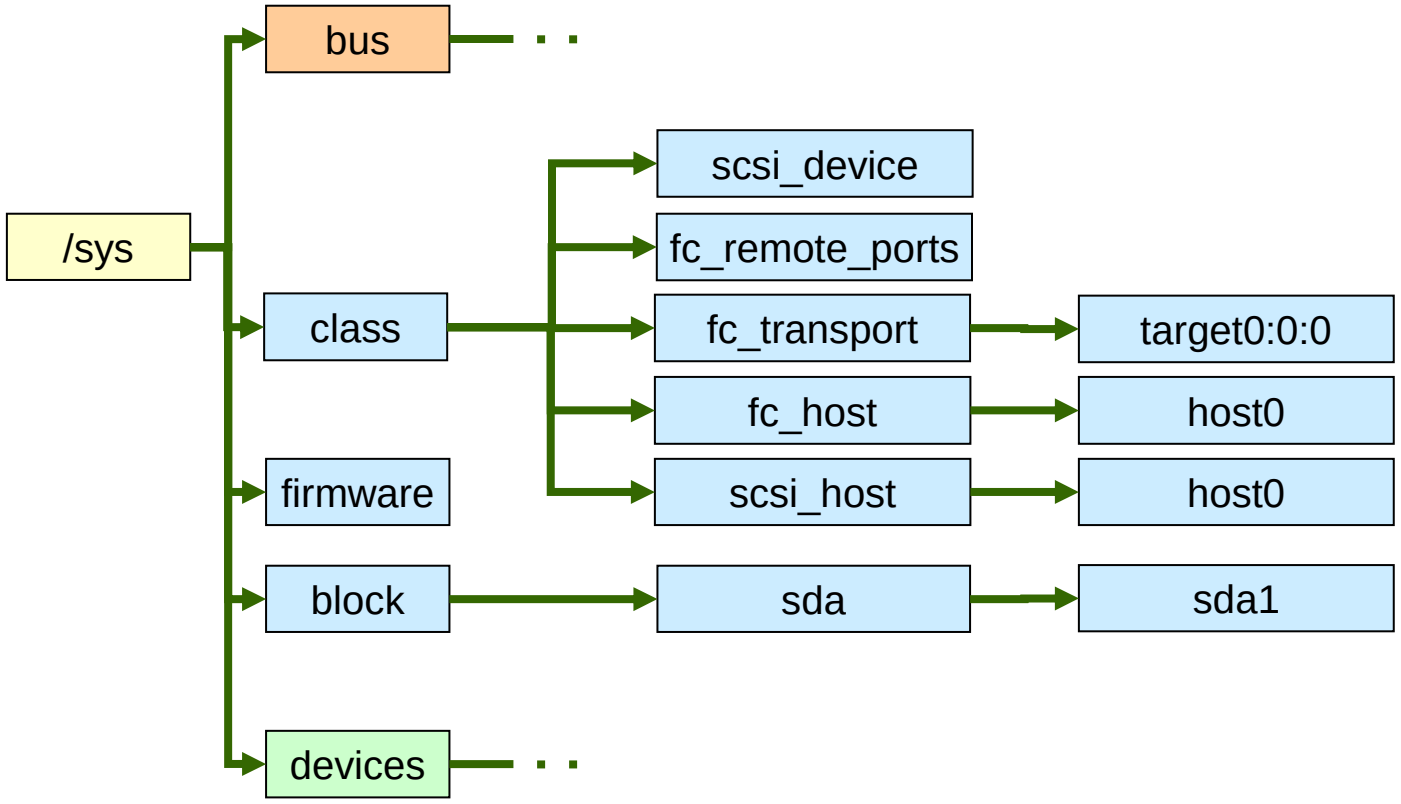
SysFS - Overview



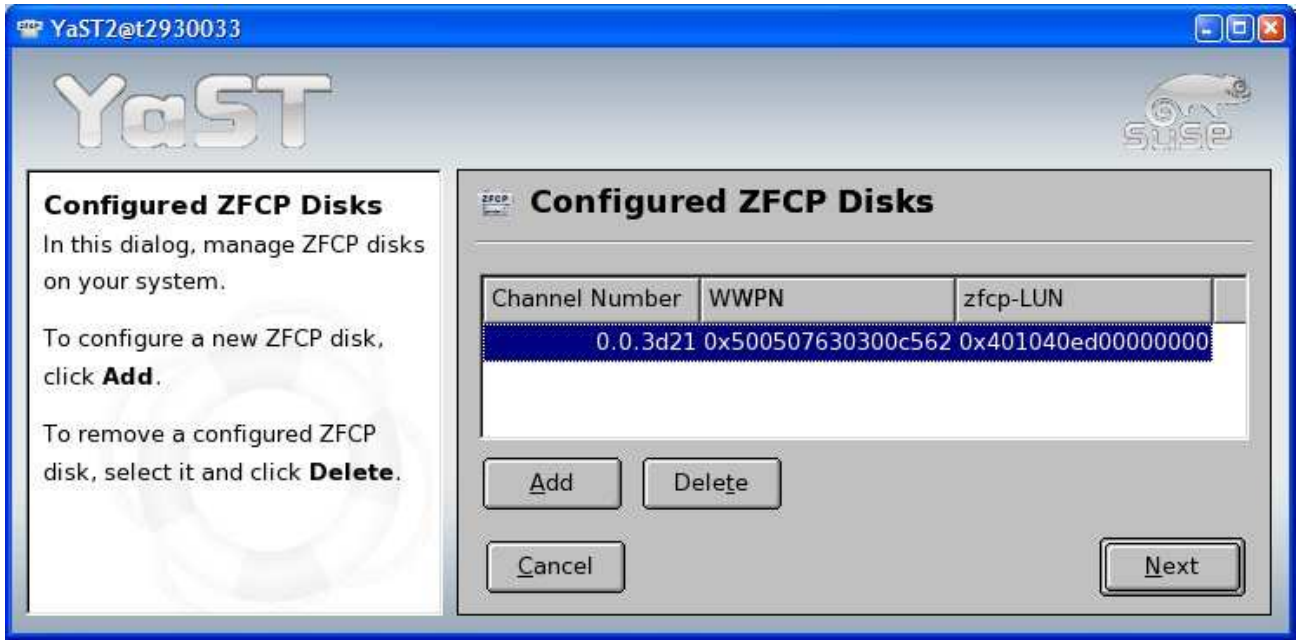


SysFS – Overview (cont)





zfcp Configuration



- **SUSE: yast**
  → hardware
  → zfcp

- **Manual zfcp configuration**

```
# cd /sys/bus/ccw/drivers/zfcp/0.0.5021/
# echo 1 > online    OR     0.0.5021 # chccwdev -e 0.0.5021
# echo 0x500507630303c562 > port_add
# echo 0x4011401600000000 > 0x500507630303c562/unit_add
```

zfcp Configuration – cont.

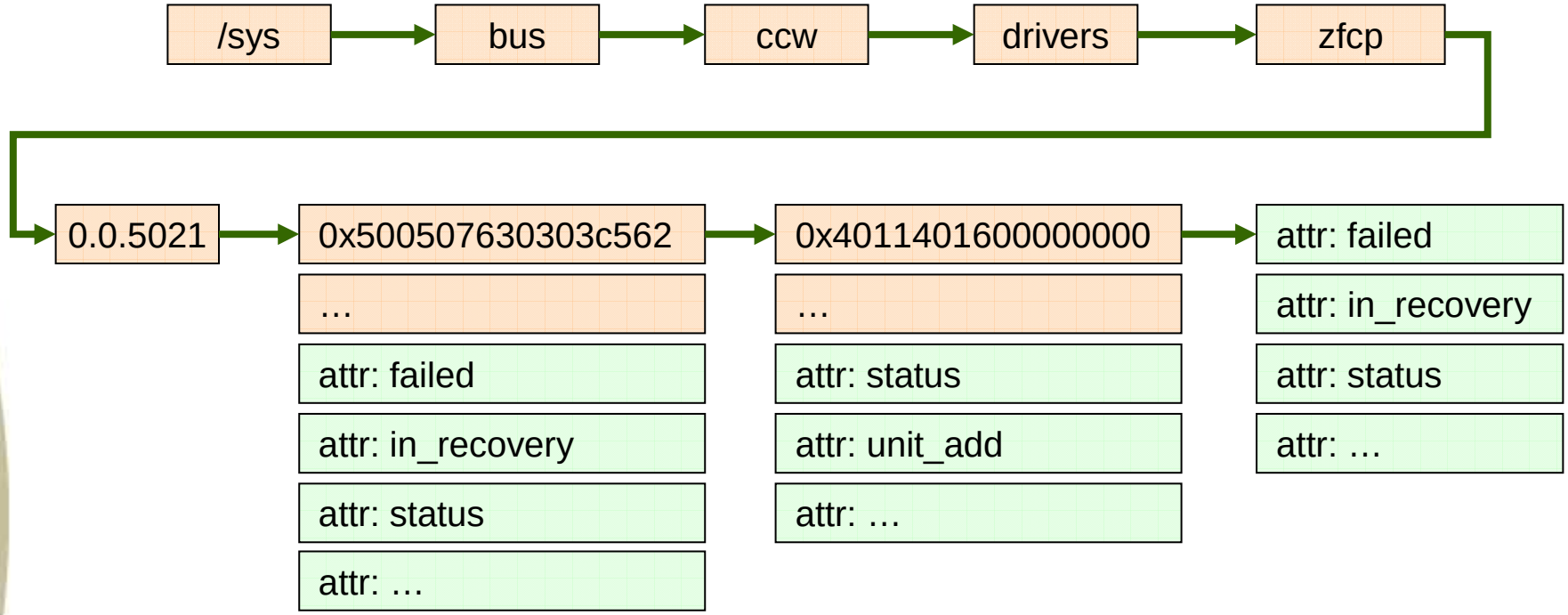
```
/var/log/messages
Jul 10 03:14:12 t2930033 kernel: scsi1 : zfcp
Jul 10 03:14:12 t2930033 kernel: zfcp: The adapter 0.0.5021 reported the following characteristics:
Jul 10 03:14:12 t2930033 kernel: WWNN 0x5005076400cd6aad, WWPN 0x5005076401008fa8, S_ID 0x00651213,
Jul 10 03:14:12 t2930033 kernel: 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)**



zfcp Adapter Information

- <directory for each configured target port>
- peer_* - point-to-point attributes
- lic_version - LIC version number
- online - adapter status (online/offline)
- failed - adapter error recovery status
- in_recovery - recovery status
- status - adapter status (debug info)

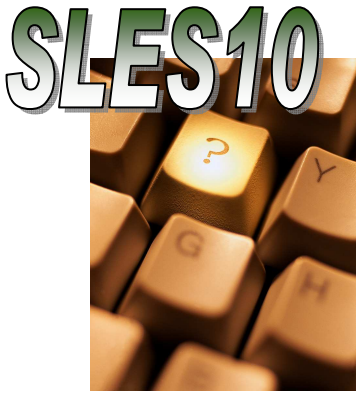
```
# cd /sys/bus/ccw/drivers/zfcp/0.0.170e
# cat lic_version
0x00000708
# cat status
0x5400082e

# lszfcp -H
0.0.170e host0
0.0.180e host1
```

zfcp Port Information

- <directory for each FCP LUN>
- access_* - access control
- failed - port error recovery status
- in_recovery - recovery status
- status - port Status (debug info)

```
# cd /sys/bus/ccw/drivers/zfcp/0.0.170e/0x500507630300c562
# ls
  0x401040ab00000000  access_denied  failed  in_recovery  status  uevent
  unit_add  unit_remove
# cat in_recovery
0
```

```
# lszfcp -P
0.0.170e/0x500507630300c562 rport-0:0-0
0.0.170e/0x500507630303c562 rport-0:0-1
0.0.180e/0x500507630303c562 rport-1:0-0
0.0.180e/0x500507630300c562 rport-1:0-1
```



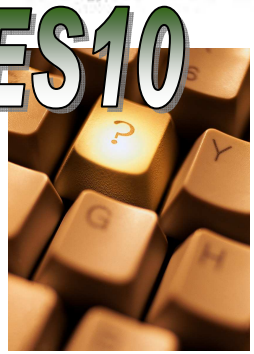
zfcp Unit Information

- **access_*** - access control
- **failed** - unit error recovery status
- **in_recovery** - recovery status
- **status** - unit status (debug info)

```
# # cd /sys/bus/ccw/drivers/zfcp/0.0.170e/0x500507630300c562/0x401040ab00000000
# ls
  access_denied  access_readonly  access_shared  failed  in_recovery  status  uevent
# cat failed
0
# cat in_recovery
0
# cat status
0x54000010
```

```
# lszfcp -D
0.0.170e/0x500507630300c562/0x401040ab00000000 0:0:0:0
0.0.170e/0x500507630303c562/0x401040ab00000000 0:0:1:0
0.0.180e/0x500507630303c562/0x401040ab00000000 1:0:0:0
0.0.180e/0x500507630300c562/0x401040ab00000000 1:0:1:0
```

Fibre Channel transport class




```
# cd /sys/class/fc_transport/
# ls
target0:0:0  target0:0:1  target1:0:0  target1:0:1
```

```
# cd target0:0:0
# ls
device    node_name
port_id   port_name
uevent
# cat node_name
0x5005076303ffc562
# cat port_id
0x652113
# cat port_name
0x500507630300c562
```

```
# cd device/0:0:0:0
# ls
block:sda         ioerr_cnt      scsi_generic:sg0
bus               iorequest_cnt  scsi_level
delete            model          state
device_blocked    queue_depth    timeout
driver            queue_type     type
fcp_lun           rescan         uevent
generic           retries        vendor
hba_id            rev            wwpn
iocounterbits     scsi_device:0:0:0:0
iodone_cnt        scsi_disk:0:0:0:0
```

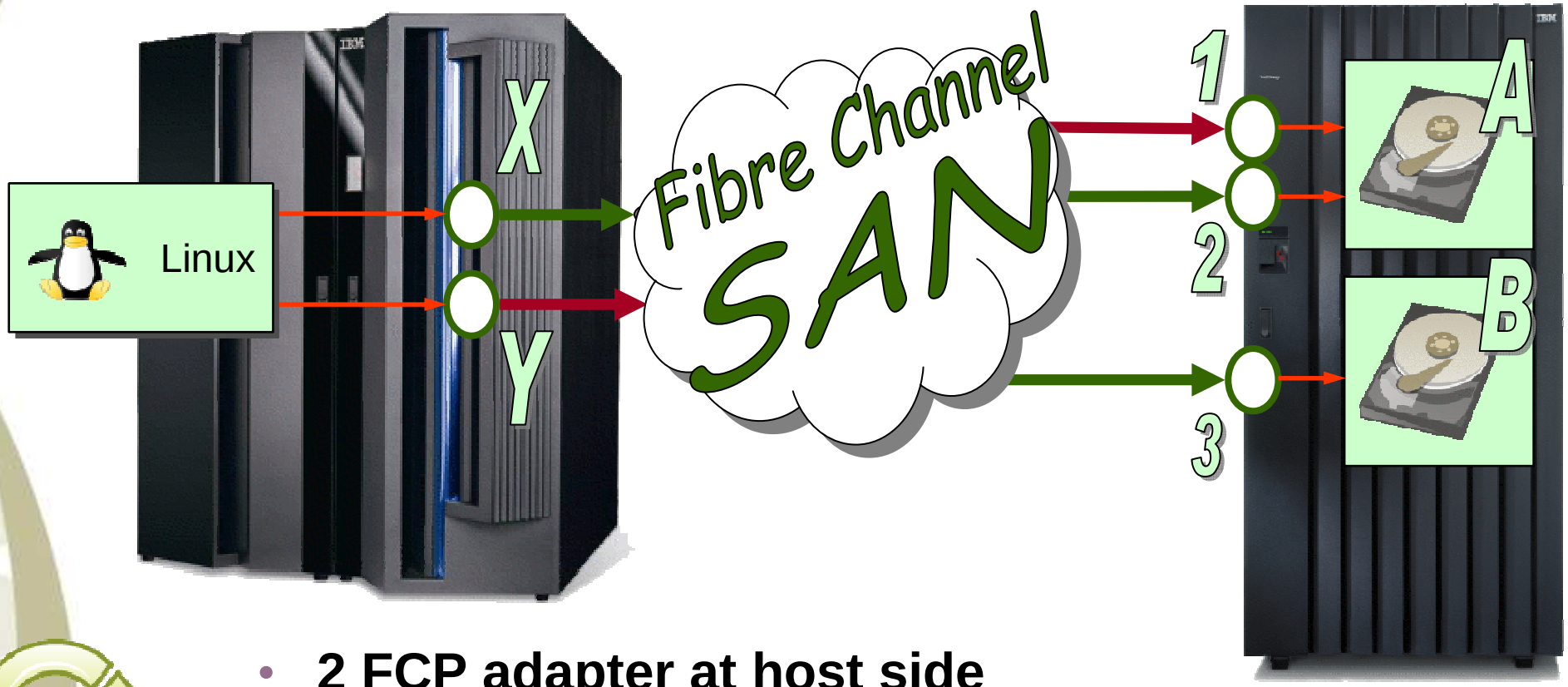
FCP Multipathing

- **“Failover” on path-failure and “failback”**
- **Load balancing**

MP-Tools
LVM
EVMS
MD
LVM2

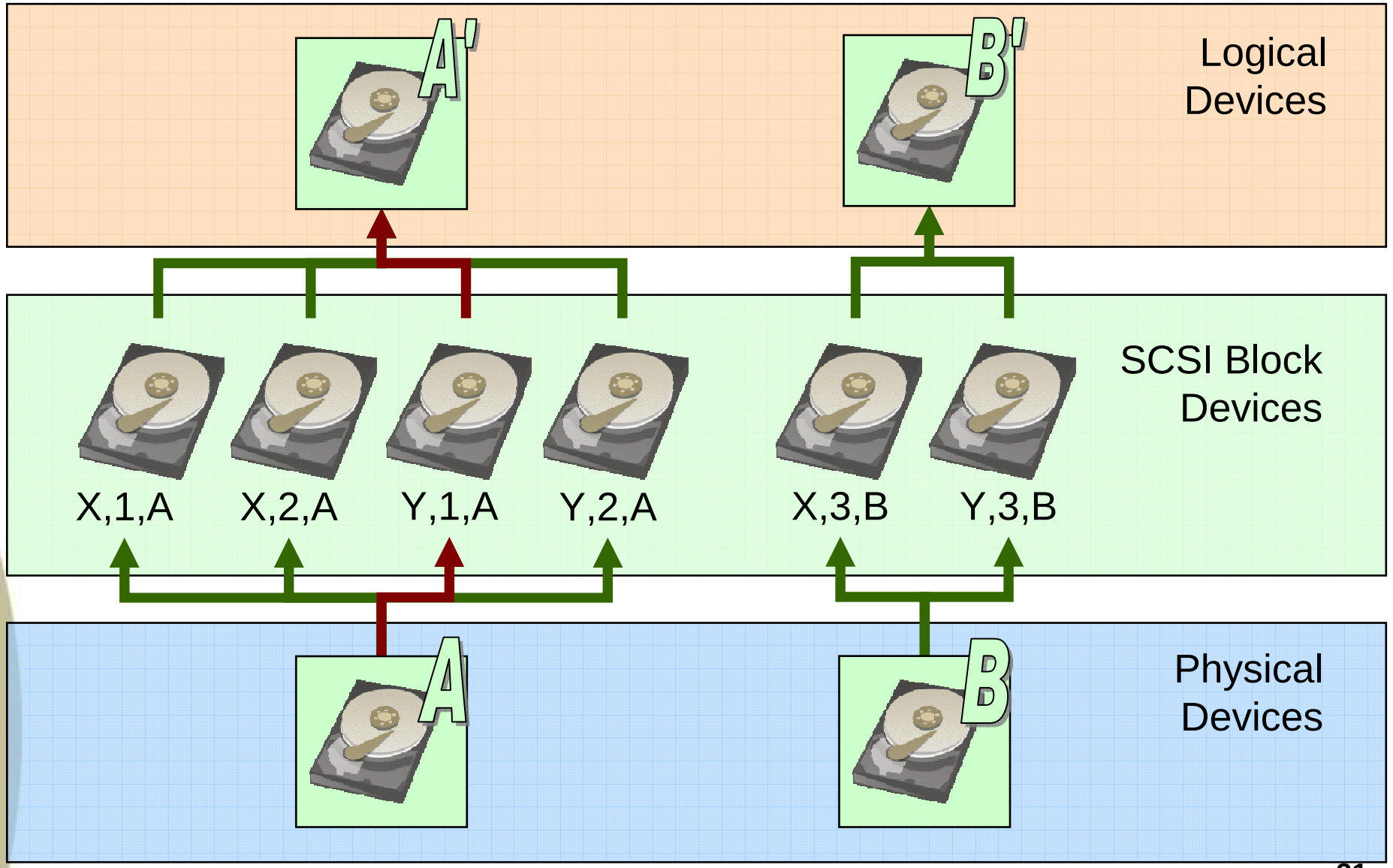
- **LVM – Logical Volume Manager**
- **Device Mapper subsystem in 2.6 kernel**
  - **EVMS – Enterprise Volume Management System**
  - **LVM2 – Logical Volume Manager 2**
  - **MP-Tools – Multipath-Tools**
- **MD – Multiple devices**

FCP Multipathing



- 2 FCP adapter at host side
- 3 FCP adapter at storage side
- 4 paths to disk A and 2 paths to disk B

FCP Multipathing – Devices



Multipath-Tools Package

```
# multipath -ll
36005076303ffc56200000000000010abdm-0 IBM,2107900
[size=5.0G][features=1
   queue_if_no_path][hwhandler=0]
\_ round-robin 0 [prio=4][active]
 \_ 0:0:0:0     sda   8:0   [active][ready]
 \_ 1:0:0:0     sdb   8:16  [active][ready]
 \_ 0:0:1:0     sdc   8:32  [active][ready]
 \_ 1:0:1:0     sdd   8:48  [active][ready]
```

- Developed by Christophe Varoqui
- Link: http://christophe.varoqui.free.fr/wiki/wakka.php?wiki=Home
- RedHat: device-mapper-multipath
- SUSE: multipath-tools
- Development ongoing

```
# cat /etc/multipath.conf
…
blacklist {
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z][[0-9]*]"
        devnode "^cciss!c[0-9]d[0-9]*[p[0-9]*]"
        devnode "^dasd[a-z]+[0-9]*"
}
…
```


```
# ls -l /dev/mapper/
total 0
brw------- 1 root root 253,  0 Aug 13 13:15 36005076303ffc56200000000000010ab
brw------- 1 root root 253,  1 Aug 13 13:15 36005076303ffc56200000000000010ab-part1
lrwxrwxrwx 1 root root      16 Aug 13 13:14 control -> ../device-mapper
```

SCSI Tape

- **Several possibilities to access SCSI tapes**
  - **st - SCSI tape device driver**
  - **sg - SCSI generic device driver**
  - **IBMtape device driver (object code only)**
  - **lin_tape device driver (open source version of IBMtape)**

- **IBMtape/lin_tape**
  - **Designed to use the features provided by the IBM tape drives**
  - **Basic tape operations (e.g. backup and restore)**
  - **Medium changer operations (e.g. mount and demount the cartridges)**
  - **Advanced functions for full tape management systems**
  - **Multipathing (2 paths)**
  - **Powerfull IBMtapeutil package**

lin_tape Device Driver

```
# ls -l /dev/IBM*
crw-rw-rw-  1 root root 254, 512 Aug 13 15:51 /dev/IBMchanger0
crw-r--r--  1 root root 254, 767 Aug  9 16:45 /dev/IBMtape
crw-rw-rw-  1 root root 254,   0 Aug 10 09:30 /dev/IBMtape0
crw-rw-rw-  1 root root 254, 256 Aug 10 09:30 /dev/IBMtape0n
```

```
# cat /proc/scsi/scsi
Host: scsi2 Channel: 00 Id: 01 Lun: 00
  Vendor: IBM Model: 03590H11 Rev: F29C
  Type: Sequential-Access ANSI SCSI revision: 03
Host: scsi2 Channel: 00 Id: 01 Lun: 01
  Vendor: IBM Model: 03590H11 Rev: F29C
  Type: Medium Changer    ANSI SCSI revision: 03
```

```
# cat /proc/scsi/IBMtape
lin_tape version: 1.6.0
lin_tape major number: 254
Attached Tape Devices:
Nr model    SN           HBA  …
0  03590H11 0000000CB722 zfcp …
```

```
# ls -l /sys/class/lin_tape/
drwxr-xr-x  2 root root 0 Aug 13 15:51 IBMchanger0
drwxr-xr-x  2 root root 0 Aug 13 15:56 IBMtape0
drwxr-xr-x  2 root root 0 Aug 10 09:30 IBMtape0n
```

```
# ls -l /etc/lin_taped.conf
-rw-r--r--  1 root root 2386 May 29 20:10 /etc/lin_taped.conf
```

```
# ps -ef | grep lin_taped
root  1192     1 0 Aug09 ?     00:00:00 /usr/bin/lin_taped start
```

IBMtapeutil Package

```
# IBMtapeutil -f /dev/IBMtape0 tur
Issuing test unit ready...
Unit ready.

# IBMtapeutil -f /dev/IBMtape0 status
Generic ANSI SCSI-2 tape drive
File number=-1, block number=0, partition=0.
Tape block size 0 bytes. Density code 0x2c
Soft error count since last status=0
General status bits on (41000000):
 BOT ONLINE

# IBMtapeutil -f /dev/IBMchanger0 elementinfo
Getting element information...

  Number of Robots ..... 1
  First Robot Address ..... 0
  Number of Slots ..... 10
  First Slot Address ..... 32
  Number of Import/Exports ..... 1
  First Import/Export Address ... 31
  Number of Drives ..... 1
  First Drive Address ..... 16
```

- General Subcommands:
  - **tur, inquiry, print, reserve, release, reqsense, qryversion, logpage, modepage, qrypath, enablepath, disablepath**
- Tape Subcommands:
  - **bsf, bsr, eof, fsf, fsr, weof, fsfm, bsfm, asf, compress, tell, seek, nocompress, rewind, sync, load, erase, display, unload, retension, read, qrypos, seod, write, setpos, status, rtest, offline, parms, wtest, rewoffl, list, rwtest, prevent, lock, setblk, allow, unlock, density, qryinquiry, qrysense, append, mtdevice, encryption**
- Medium Changer Subcommands:
  - **allow, prevent, audit, inventory, mount, position, elementinfo, unmount, move, devids, exchange**
- Service Aid Subcommands:
  - **dump, forcedump, ucode, resetdrive**

SAN Discovery Tool

- **Identification of SAN resources**
  - List of host adapters, ports, units
- **Helpful to uncover configuration problems**
  - E.g. zoning or LUN masking problems
- **Does not configure zfcp automatically**

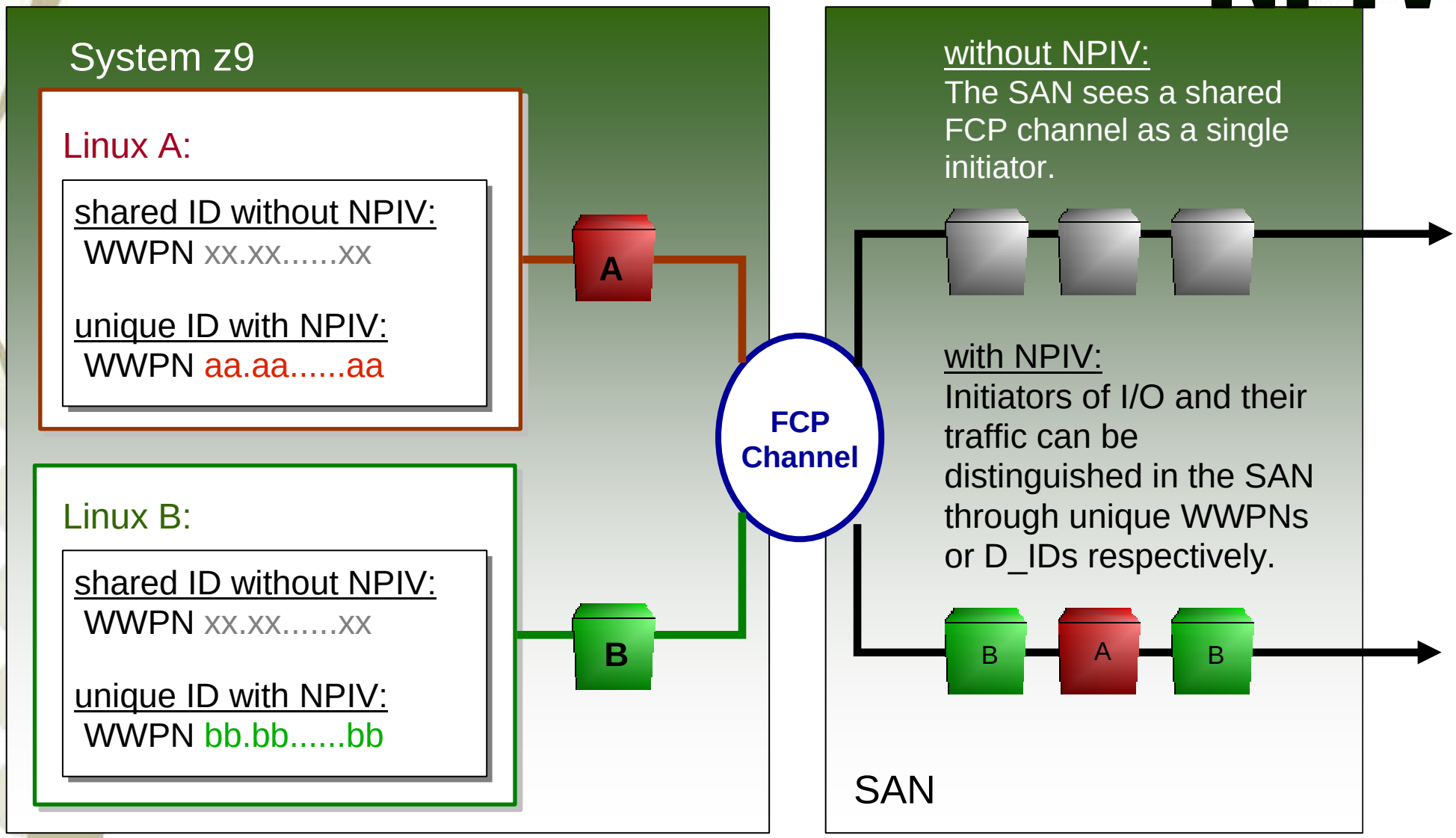
```
# san_disc -c PORT_LIST -a 1
 #  Port WWN           Node WWN           DID      Type
  1 0x500507640140863c 0x5005076400cd6aad 0x650613 N_Port
  2 0x50050764010087ef 0x5005076400cd6aad 0x650713 N_Port
    ...
 97 0x500507640140863c 0x5005076400cd6abd 0x650613 N_Port
```

Port list

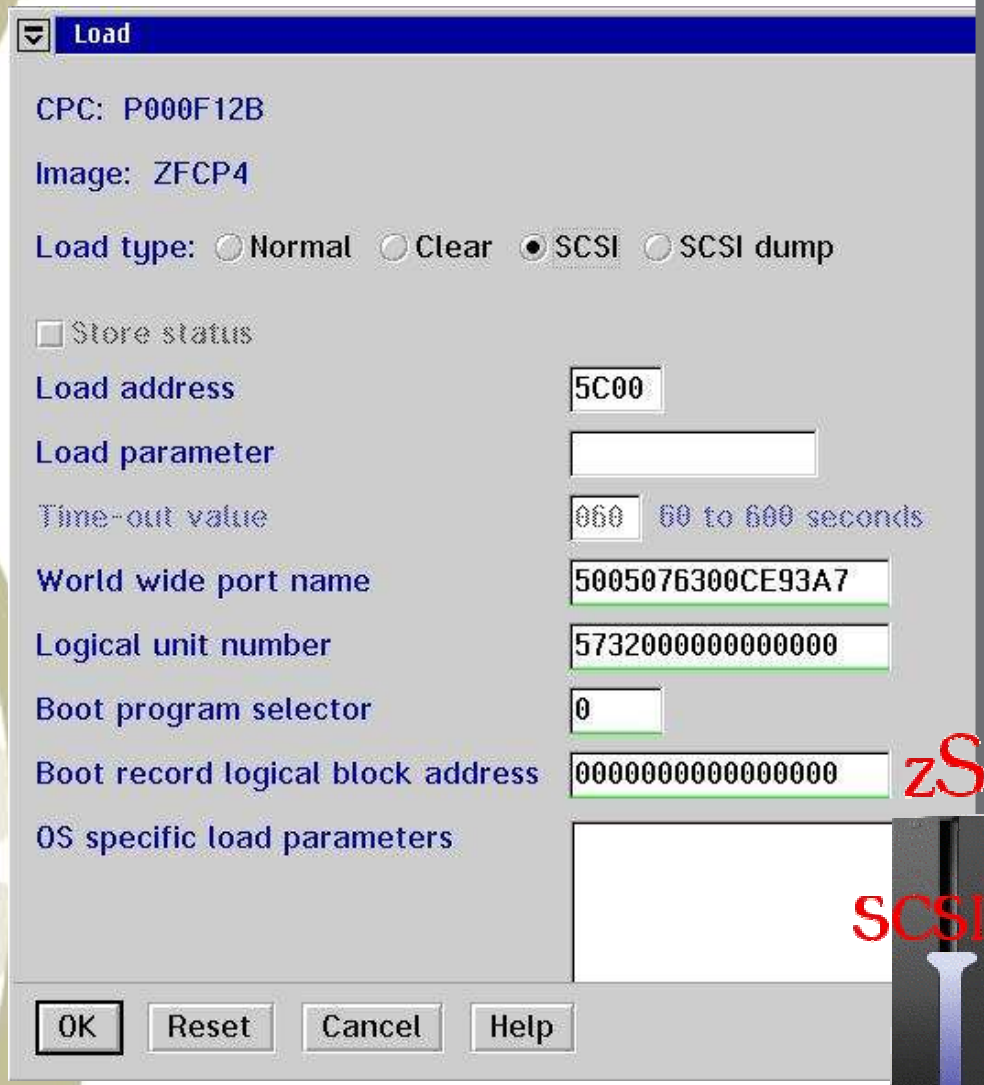
```
# san_disc -c REPORT_LUNS -a 1 -p 0x500507640140863c
Number of LUNs: 97
#    LUN
   1 0x4010400000000000
   2 0x4010400100000000
     ...
  97 0x4010406000000000
```

LUN list

NPIV – N-Port ID Virtualization



SCSI IPL & SCSI Dump



- **IPL from SCSI disks**
- **Dump to SCSI disks (LPAR only).**
- **SCSI IPL expand the set of IPL'able devices**
- **SCSI disks as Linux root file system possible**
- **New set of IPL parameters.**
- **LPAR and z/VM guests supported.**

Requirements

- **z800, z890, z900, z990, z9**
- **Requires enablement by FC9904**
- **FCP Channels**
- **FC attached SCSI Disks**

SCSI IPL – example z/VM

```
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
```

Summary

- **FCP/SCSI support for IBM System z**
- **Integration of your System z into standard based FC SANs**
- **FCP channel based on FICON / FICON Express adapter cards**
- **Three addressing parameters instead of one**
- **Many information hidden in sysfs**
- **Performance and other advantages compared to ECKD**
- **If possible use multipathing**
- **If possible use NPIV**
- **Helpful SAN discovery tool**

- **Give it a try, you probably have all you need.**

Useful Links

- I/O Connectivity on System z
  - http://www-03.ibm.com/systems/z/connectivity/
- Getting Started with zSeries Fiber Channel Protocol, IBM Redpaper
  - http://www.redbooks.ibm.com/redpapers/pdfs/redp0205.pdf
- z/VM
  - Version 5.3: http://www.vm.ibm.com/zvm530/
- Introducing N_Port Identifier Virtualization for IBM System z9 (Redpaper)
  - http://www.redbooks.ibm.com/redpapers/pdfs/redp4125.pdf
- 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
- Linux for IBM System z
  - http://www-128.ibm.com/developerworks/linux/linux390/
- 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)
- IBM TotalStorage Tape Device Drivers – Installation and User‘s Guide
  - ftp://ftp.software.ibm.com/storage/devdrvr/Doc/
- IBM disk systems
  - http://www-03.ibm.com/servers/storage/disk/
- linuxvm.org
  - http://www.linuxvm.org/

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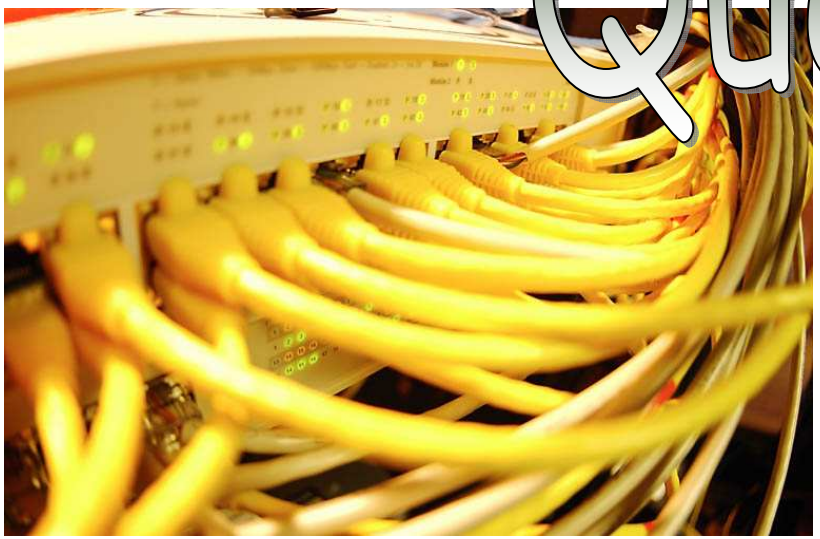

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Making Your Penguins Fly
Introduction to SCSI over FCP for Linux on System z
Horst Hummel