SCSI on Linux for zSeries – Early Experiences

Neale Ferguson
Software AG
August 2002

Thanks

- Software AG began participation in the ESP in July, 2002
- IBM have authorized Software AG to present this material
- Thanks for their assistance during the ESP goes to:
  - Ingolf Salm – IBM Germany
  - Pam Hares – IBM UK
  - Christoph Arenz – IBM Germany (& US)

Acknowledgements

- Uli Kuhna – for SAN and Shark configuration
- Wolfgang Buettner – for z/VM & IOCDS configuration
- Dr. Gerhard Banzhaf (IBM) – material from his presentation “FCP Channel for z800 and z900”
- Material adapted from “Device Drivers and Installation Commands”.
- Material sourced from “Getting Started with zSeries Fibre Channel Protocol”.

Agenda

- Background
- Environment
- Configuration
- 31-bit Experiences
- 64-bit Experiences
- Further work

Background

- Allows Linux for S/390 (31-bit mode) and Linux for zSeries (64 bit mode) to access:
  - Distributed storage devices
    - With FCP interfaces (via switches)
    - With parallel SCSI interfaces (via additional bridges)
  - With Linux for zSeries (S/390) running
    - In a partition
    - Under z/VM (requires z/VM 4.3 RSU001)
- Provides access to distributed (open) storage and SAN world
- Based on existing FICON and FICON Express hardware

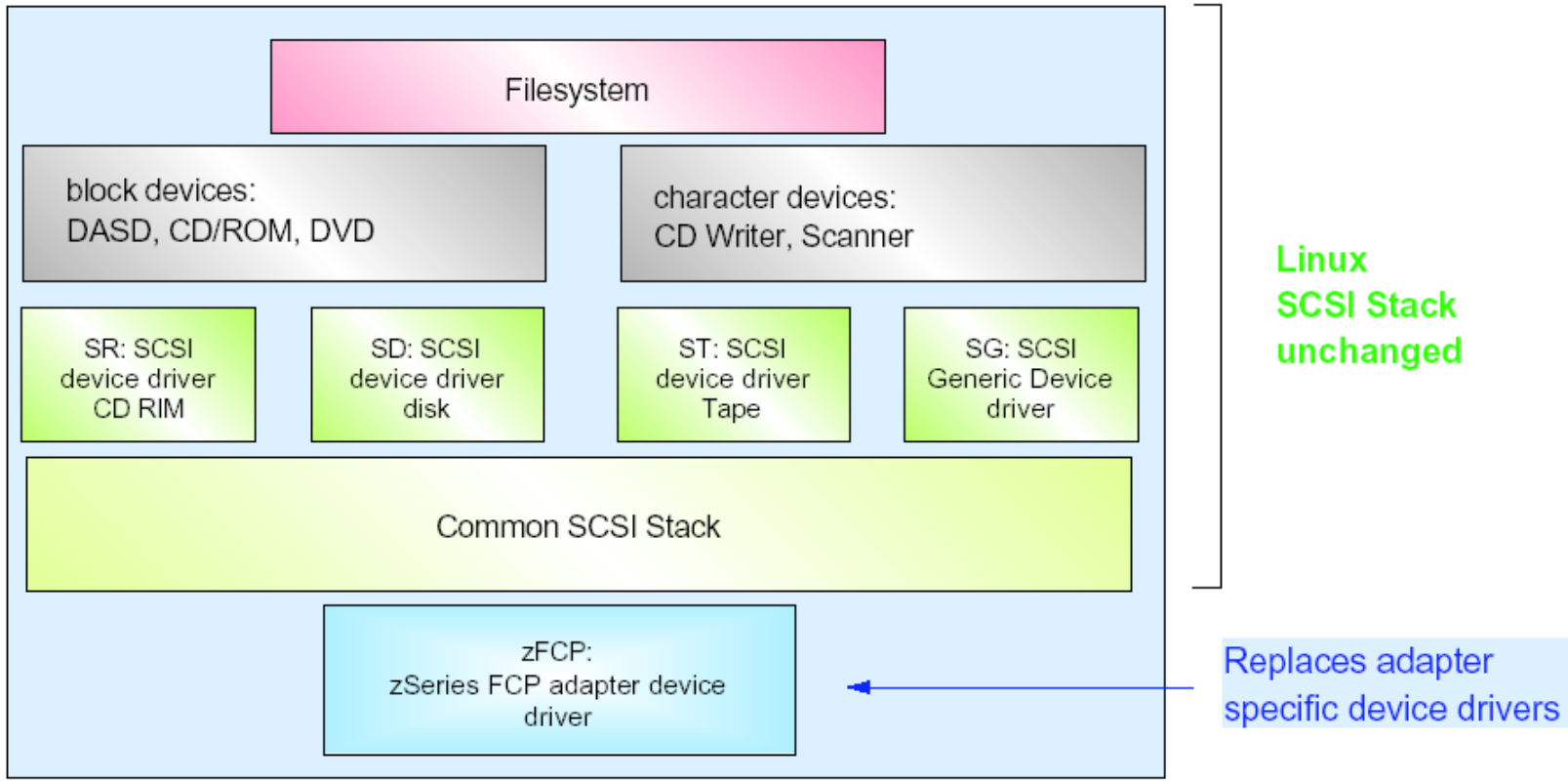
Background

- New CHPID type: FCP
- Uses 2-port Fibre Channel cards FICON and FICON Express
  - Optical only
  - Short wave and long wave
  - 1 Gbit/s today: 2 Gbit/s has been announced
  - Currently 232KB buffer in card: 2MB proposed
- Different Firmware Load
  - Selected via definition of CHPID type in IOCP (HCD)
- QDIO protocol for communication between Processor/Memory and Channel
  - Based on scheme introduced with OSA Express
  - Continuously running channel programs
    - Reduces I/O path lengths
    - Reduces number of interrupts

Background

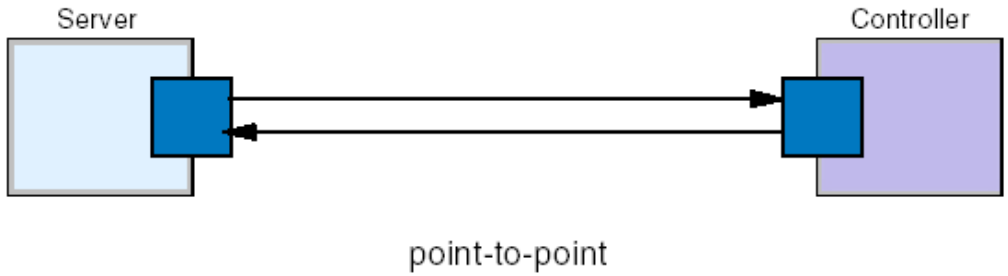
- The zfcp driver is a low-level or host-bus adapter driver supplementing the Linux SCSI I/O subsystem (SCSI stack).
- zfcp driver is open source.
- Linux for zSeries and S/390 can make use of all SCSI device types currently supported by Linux on other platforms including
  - SCSI disks,
  - Tapes,
  - CD-ROMs, and ,
  - DVDs.

Background

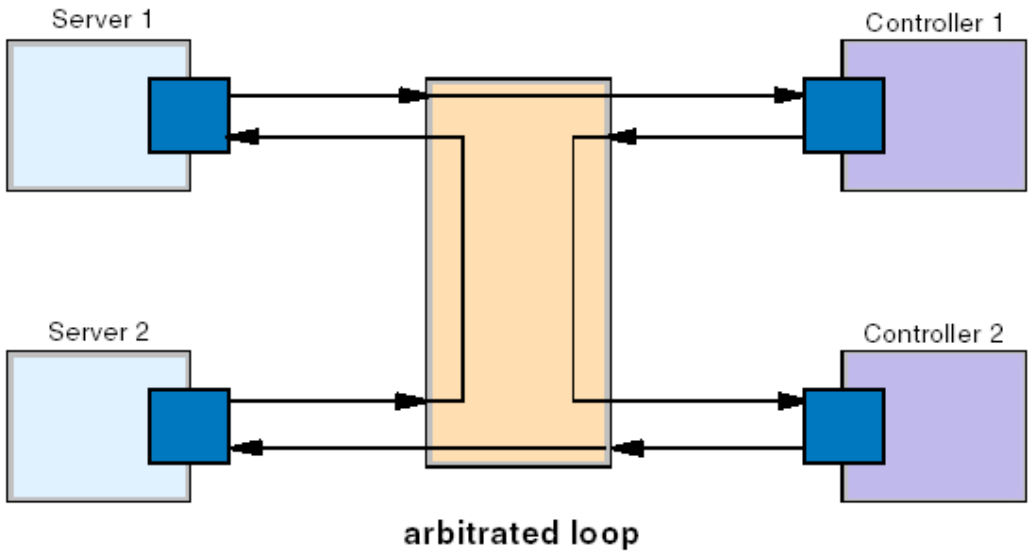

Filesystem
block devices:
DASD, CD/ROM, DVD
character devices:
CD Writer, Scanner
SR: SCSI
device driver
CD RIM
SD: SCSI
device driver
disk
ST: SCSI
device driver
Tape
SG: SCSI
Generic Device
driver
Common SCSI Stack
zFCP:
zSeries FCP adapter device
driver
Linux
SCSI Stack
unchanged
Replaces adapter
specific device drivers

SAN Topologies

- Point-to-point

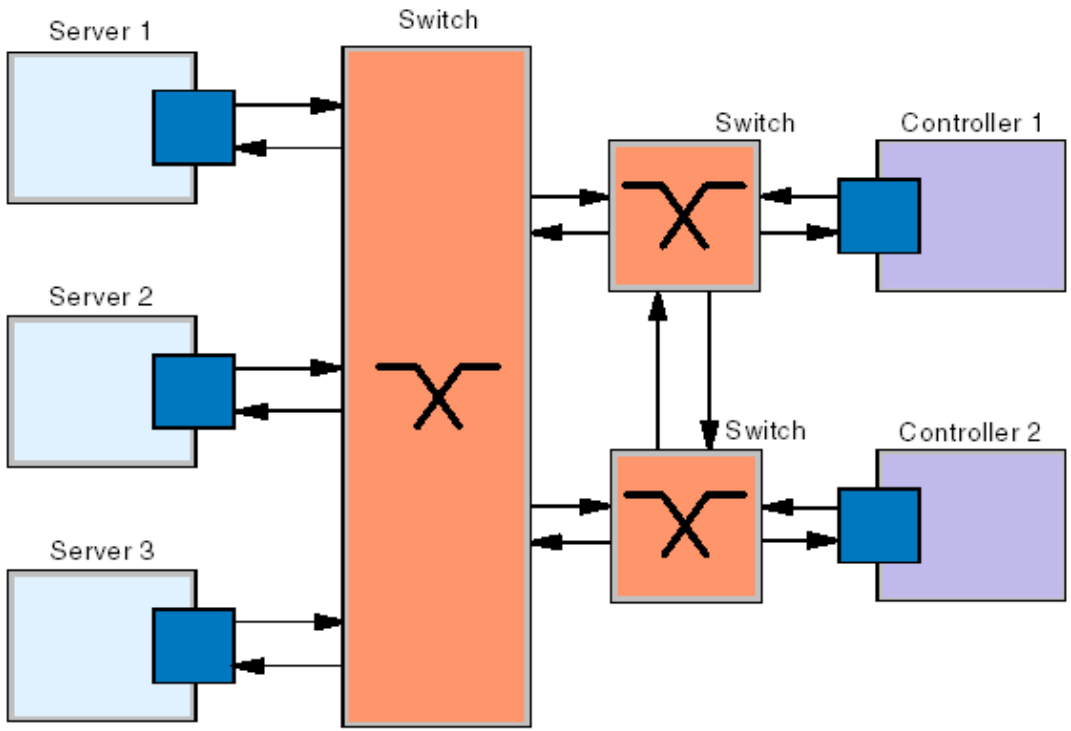


- Arbitrated Loop



SAN Topologies

- Switched Fabric



switched fabric

Environment

- Hardware

Component	Model	Microcode Level
IBM z900	2064-103	J11233.003 FCP OFCP15 Level 0.1A
McData SAN Switch	Connectrix ED-64M	01.04.002
Shark ESS	2105-F20	1.5.0.107

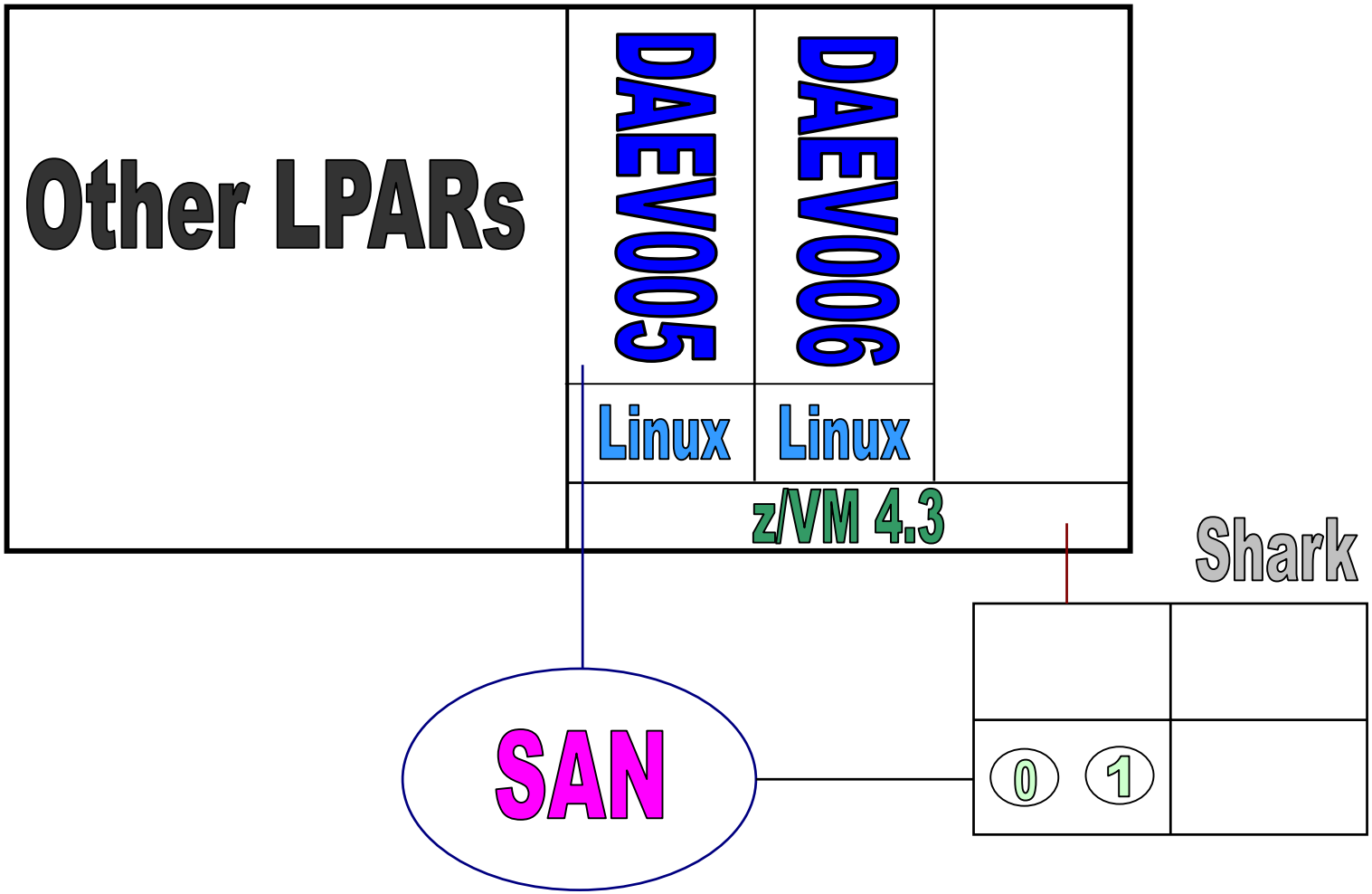
- Software

Component	Function	Level
z/VM	Hypervisor	4.3 RSU 001
Linux for S/390	31-bit kernel	2.4.7+
Linux for zSeries	64-bit kernel	2.4.17+
ESM Manager	SAN Manager	2.0

Environment

- Linux details
  - CONFIG_MSDOS_PARTITION=y
  - CONFIG_ZFCP=m
  - New utils-linux – `fdisk` required
  - Will (eventually) need new devs.rpm but not mandatory
  - Manuals geared towards devfs but we were using SLES7

Environment



Configuration

- z/VM User Directory

```
**** PROFILE LNXGST for LINUX Guests
PROFILE LNXGST
 MACHINE ESA
 OPTION QUICKDSP
 SHARE REL 1000
 IPL CMS PARM AUTOCR
 CONSOLE 009 3215 T OPERATOR
 SPOOL 00C 2540 READER *
 SPOOL 00D 2540 PUNCH  A
 SPOOL 00E 1403 A
 LINK MAINT 190 190 RR
 LINK MAINT 19D 19D RR
 LINK MAINT 19E 19E RR
*
USER DAEV005 ******** 256M 512M G
   INCLUDE LNXGST
   ACCOUNT LINUX R.WAITE
   MDISK 0191 3390 2651 0025 VVSYS1 MR
   MDISK 0192 3390 0001 2838 VVTL99 MR
   MDISK 0193 3390 2839 0500 VVTL99 MR
   SPECIAL E00A CTCA TCPIP
   SPECIAL E00B CTCA TCPIP
* HyperSockets with MTU size of 8k
   DEDICATE D10 D10
   DEDICATE D11 D11
   DEDICATE D12 D12
```

```
USER DAEV006 ******** 256M 512M G
   INCLUDE LNXGST
   ACCOUNT LINUX R.WAITE
   MDISK 0191 3390 2676 0025 VVSYS1 MR
   MDISK 0192 3390 3839 2838 VVTL99 MR
   MDISK 0193 3390 3339 0500 VVTL99 MR
   SPECIAL E00C CTCA TCPIP
   SPECIAL E00D CTCA TCPIP
* HyperSockets with MTU size of 8k
   DEDICATE D04 D04
   DEDICATE D05 D05
   DEDICATE D06 D06
```

Note: The SCSI device ‘E000’ was ATTACHed to each user as required:

```
FCP  E000 ATTACHED TO DAEV006  E000 CHPID E0
```

Configuration

- IOCDS

```
CHPID PATH=(E0),SHARED,
          PARTITION=((DAEV,DAEX,DALI),(DAEV,DAEX,DALI)),TYPE=FCP
CNTLUNIT CUNUMBR=E0FC,PATH=(E0),UNIT=FCP
IODEVICE ADDRESS=(E000,016),CUNUMBR=(E0FC),UNIT=FCP
```

Configuration

- CHPID/Device/SCSI Device
  - S390 device != SCSI device
  - S390 device is conduit to SCSI
  - May be 1,…,*n* SCSI devices at end of conduit
  - Each SCSI device may be partitioned to produce multiple targets

Configuration

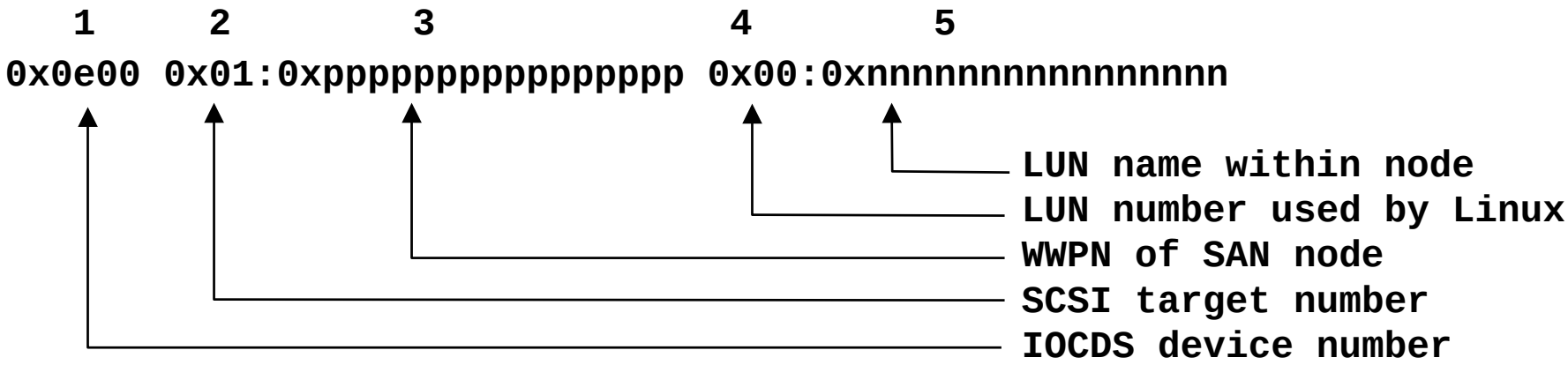
- A new addressing scheme was developed for Fibre Channel Protocol (FCP) usage, built around World Wide Names (WWN) that are eight bytes long.
- Part of the name represents an address type, part is a number that identifies the manufacturer, and part is a unique number assigned (by the manufacturer) for each port or node.
- A node is typically a box that contains information. Nodes have one or more ports (and only FC ports are relevant here). A given box may have several addresses; one for the node itself, and one for each FC port contained in the node. Abbreviations are:
  - WWNN is a World Wide Node Name
  - WWPN is a World Wide Port Name
  - WWN is any World Wide Name (WWNN or WWNP)

Configuration

- Linux provides extensive support for SCSI devices, based on the more advanced forms of traditional SCSI addressing.
- A SCSI device is expected to have a number (target address, typically a single digit) and this target may have multiple LUNs.
- The full SCSI addressing scheme can be used:
  - Device number (from your IOCDS) (coded as a “host number”)
  - A bus number on this adapter (always zero in current zSeries implementations)
  - A SCSI target number on this bus
  - A LUN number on this SCSI target
  - A partition or device within this LUN

Configuration

- FCP Mapping



Configuration

1. Device number
   - This device number must be defined in the IOCDS and be assigned to the FCP channel attached to the FCP switch.
     - You can use the same device number for all your FCP connections (by a given Linux image), or,
     - You can elect to use multiple device numbers (all assigned to the FCP channel, of course).

Configuration

2. Target number
   - The standard Linux SCSI support understands traditional SCSI addressing, with adapter numbers, bus numbers, target ("SCSI address") numbers, and LUNs.
   - You assign this number.
   - Usable target addresses range from 1 to any positive 31-bit number.
   - Traditional SCSI target addresses ranged from 0-7 or 0-15. More recent SCSI architecture allows a much larger number.

Configuration

3. WWPN
   - The World Wide Port Name of the device containing the LUN.
   - The WWPN *as seen by the FC switche*s. WWPNs reported by devices may be slightly different.
   - You do not assign this number; it is built into the FCP devices and you must determine the proper number by querying your FCP elements.

Configuration

4. Linux LUN
   - The number *to be used by* Linux.
   - You assign this number.
   - Normal usage is to start with 0 and to increment by one for each LUN.
5. SAN Device LUN
   - The number used by the remote device.
   - You do not assign this number.
   - You must determine the number assigned by the node controller.

Configuration

- There are different parameters that can or must be supplied by the user to allow for proper zfcp operation:
  - Address mappings between Linux SCSI and FCP schemes (optional for each SCSI target)
  - Logging level to determine the verbosity of the zfcp device driver (optional, default value is used if not supplied)

Configuration

- The zfcp driver provides different means of configuration:
  - Kernel parameters
  - Module parameters (such as for use in `modules.conf`)
  - Various proc file system entries in `/proc/scsi/zfcp`

Configuration

- Module Parameters and proc File System entries

Function	Module Parameter	Kernel Parameter	proc-fs entry
Set logging level	loglevel zfcp_	loglevel	/proc/scsi/zfcp/mod_parm
Get logging level (and other global module information)	N/A	N/A	/proc/scsi/zfcp/mod_parm
Add address mapping(s)	map	zfcp_map	/proc/scsi/zfcp/add_map
Get all existing address mappings	N/A	N/A	/proc/scsi/zfcp/map

Configuration

- Additional device nodes:

```
mknod /dev/sda  b 8 0
mknod /dev/sda1 b 8 1
mknod /dev/sda2 b 8 2
mknod /dev/sda3 b 8 3
mknod /dev/sda4 b 8 4
mknod /dev/sda5 b 8 5
mknod /dev/sda6 b 8 6
mknod /dev/sda7 b 8 7
mknod /dev/sda8 b 8 8
mknod /dev/sdb  b 8 16
mknod /dev/sdb1 b 8 17
mknod /dev/sdb2 b 8 18
mknod /dev/sdb3 b 8 19
mknod /dev/sdb4 b 8 20
```

Configuration

- Devices

Target	Logical Unit	Size	Device Name
0	0	25GB	/dev/sda1
	1	50GB	/dev/sda2
	2	25GB	/dev/sda3
	3	25GB	/dev/sda4
1	0	5GB	/dev/sdb1
	1	5GB	/dev/sdb2

Configuration

- Driver load script
  - `ln -s /etc/init.d/scsi_load /etc/init.d/rc3.d/S12scsild`

```
#!/bin/sh
rmmod zfcp
modprobe qdio
modprobe scsi_mod
insmod zfcp loglevel=0 map="\
0xe000 0x01:0x5005076300c38c6d 0x00:0x5200000000000000;\
0xe000 0x01:0x5005076300c38c6d 0x01:0x5201000000000000"
modprobe sd_mod
modprobe st
```

Configuration

- During scsi_load:

```
scsi0 : zfcp
  Vendor: IBM       Model: 2105F20           Rev: .107
  Type:   Direct-Access                      ANSI SCSI revision: 03
Attached scsi disk sda at scsi0, channel 0, id 1, lun 0
zfcp: FSF: zfcp_fsf_send_fcp_command_task_handler: status for SCSI Command:
00000000 0000
zfcp: FSF: zfcp_fsf_send_fcp_command_task_handler: SCSI status code 0x2
00000000 00000000 00000202 00000000 00000020 00000000
70000600 00000018 00000000 29000000 00000000 00000000 00000000 00000000

SCSI device sda: 195312512 512-byte hdwr sectors (100000 MB)
 dasdbm:(nonl)/        : dasdbm1
```

Configuration

- Following scsi_load:

```
Module                  Size  Used by
st                     27696   0  (unused)
sd_mod                 12048   0  (unused)
zfcp                  345312   0
scsi_mod               61344   3  [st sd_mod zfcp]
nfsd                   69648   4  (autoclean)
qeth                  153072   1  (autoclean)
qdio                   33968   2  (autoclean) [zfcp qeth]
ipv6                  247472  -1  (autoclean) [qeth]
8021q                  12928   0  (autoclean) [qeth]
ctc                    49840   1  (autoclean)
fsm                     1920   0  (autoclean) [ctc]
```

Configuration

- Partitioning using `fdisk`:

```
Disk /dev/sda: 255 heads, 63 sectors, 12157 cylinders
Units = cylinders of 16065 * 512 bytes

   Device Boot      Start         End      Blocks   Id  System
/dev/sda1               1        3188    25607578+  83  Linux
/dev/sda2            3189        6376    25607610   83  Linux
/dev/sda3            6377       12157    46435882+  83  Linux

Command (m for help): w
The partition table has been altered!

Calling ioctl() to re-read partition table.
Syncing disks.
```

Configuration

- Mounting devices
  - **`ln –s /etc/init.d/scsi_mount /etc/init.d/rc3.d/S12scsimn`**

```
#!/bin/sh
mount /dev/sda1 /FS/scsi01
mount /dev/sda2 /FS/scsi02
mount /dev/sda3 /FS/scsi03
mount /dev/sdb1 /FS/scsi04
mount /dev/sdb2 /FS/scsi05
```

Configuration

- Unmounting devices
  - `ln –s scsi_unmount rc3.d/K13scsium`

```
#!/bin/sh
umount /FS/scsi01
umount /FS/scsi02
umount /FS/scsi03
umount /FS/scsi04
umount /FS/scsi05
```

Configuration

- Contents of `/proc/partitions`:

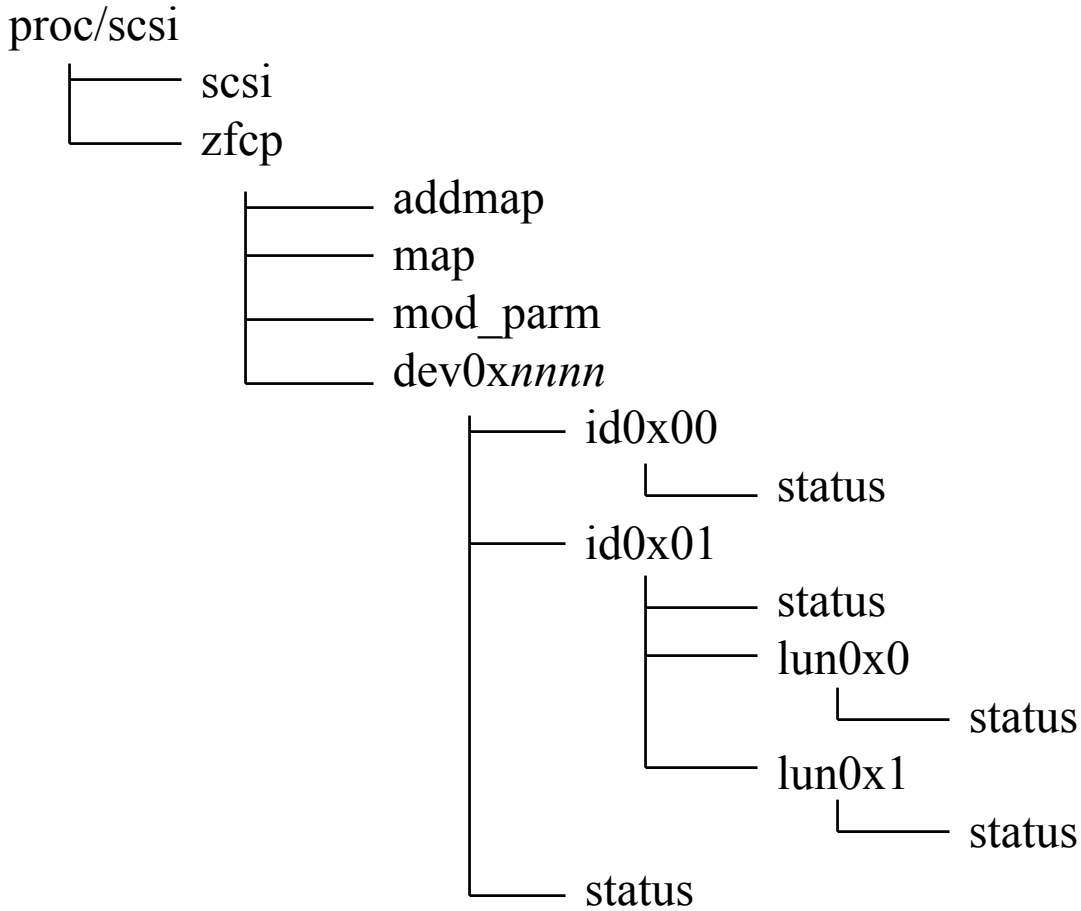
```
major minor  #blocks  name

   8     0   97656256 dasdbm
   8     1   25607578 dasdbm1
   8     2   25607610 dasdbm2
   8     3   46435882 dasdbm3
   8    16    9765632 dasdbn
   8    17    5121008 dasdbn1
   8    18    4643840 dasdbn2
  94     0     360000 dasda
  94     1     359988 dasda1
  94     4    2043360 dasdb
  94     5    2043348 dasdb1
```

➢ Suspect device naming due to IBM Partitioning being enabled

Configuration

- proc Filesystem has lots of SCSI information:



Configuration

- Contents of `/proc/scsi/scsi`:

```
Attached devices:
Host: scsi0 Channel: 00 Id: 01 Lun: 00
  Vendor: IBM      Model: 2105F20          Rev: .107
  Type:   Direct-Access                    ANSI SCSI revision: 03
Host: scsi0 Channel: 00 Id: 01 Lun: 01
  Vendor: IBM      Model: 2105F20          Rev: .107
  Type:   Direct-Access                    ANSI SCSI revision: 03
```

Configuration

- Contents of `/proc/scsi/zfcp/dev0xe000/status`:

```
FCP adapter

FCP driver $Revision: 3.60.4.1 $ (or for cryptography's sake 0x0003003c)

device number:            0xe000     registered on irq:             0x0013
WWNN:         0x5005076400c67100
WWPN:         0x50050764012006f6     S_ID:                        0x611413
HW version:               0x0002     LIC version:               0x0000001a
FC link speed:            1 Gb/s     FC service class:                   3
FC topology:   fabric
SCSI host number:     0x00000000

Attached ports:                2     QTCB size (bytes):              1696
Max SCSI ID of ports: 0x00000001     Max SCSI LUN of ports:     0x00000001
FSF req seq. no:      0x003d03c8     FSF reqs active:                  16
Scatter-gather table-size:    57     Max no of queued commands:      4096
Uses clustering:               1     Uses New Error-Handling Code:      1
ERP counter:          0x00000000     Adapter Status:            0x5400006f

Adapter Structure information:
Common Magic:         0xfcfcfcfc     Specific Magic:            0xaaaaaaaa
Adapter struct at:    0x0de25000     List head at:              0x0de25008
Next list head:       0x109d82b0     Previous list head:        0x109d82b0

Scsi_Host struct at:  0x0d868400
Port list head at:    0x0de250a0
Next list head:       0x0d869808     Previous list head:        0x0d868808
List lock:            0x00000000     List lock owner PC:        0x00000000
```

Configuration

- /proc/scsi/zfcp/dev0xe000/status (cont.):

```
O-FCP req list head:  0x0de250d0
Next list head:       0x0d89c608     Previous list head:       0x0d87a608
List lock:            0x00000000     List lock owner PC:       0x00000000

Request queue at:     0x0de250f8
Free index:                 002      Free count:                    128
List lock:            0x00000000     List lock owner PC:       0x00000000
current TOD:          1326383201267704016O
time lock held:       35007809781

Response queue at:    0x0de25550
Free index:                 072      Free count:                    000
List lock:            0x00000000     List lock owner PC:       0x00000000

DEVICE INFORMATION (devinfo):
Status: "OK"
Control Unit Type:        0x1731     Control Unit Model:            0x03
Device Type:              0x1732     Device Model:                  0x03
CIWs:       0x40720080 0x41830004 0x42820040 0x431b1000
            0x441f0000 0x00000000 0x00000000 0x00000000

DEVICE INFORMATION (devstat):
Interrupt Parameter:  0x00000002     Last path used mask:           0x00
Channel Status:             0x80     Device Status:                 0x00
Flag:                 0x00000204     CCW address (from irb):   0x0d863a40
Response count:       0x00000000     Sense Count:              0x00000000
IRB:        0x00c0c0c9 0x0d863a40 0x00800000 0x00000000
Sense Data: 0x00000000 0x00000000 0x00000000 0x00000000
```

Configuration

- Contents of …/dev0xe000/id0x01/status:

```
Port Information:

WWNN:          0x0000000000000000     WWPN:               0x5005076300c38c6d
SCSI-ID:               0x00000001     Max SCSI lun:              0x00000001
D-ID:                  0x00614013
Handle:                0x00000025

Attached units:                 2
ERP counter:           0x00000000
Port Status:           0x54000003

Port Structure information:
Common Magic:          0xfcfcfcfc     Specific Magic:            0xbbbbbbbb
Port struct at:        0x0d869800     List head at:              0x0d869808
Next list head:        0x0d868808     Previous list head:        0x0de250a0

Unit list head at:     0x0d869820
Next list head:        0x0d869508     Previous list head:        0x0d869208
List lock:             0x00000000     List lock owner PC:        0x00000000

Parent adapter at:     0x0de25000
```

Configuration

- Contents of .../id0x01/lun0x0/status:

```
Unit Information:

SCSI lun:               0x00000000      FCP lun:            0x5200000000000000
Handle:                 0x0000001d

ERP counter:            0x00000000
Unit Status:            0x54000000

Unit Structure information:
Common Magic:           0xfcfcfcfc      Specific Magic:             0xcccccccc
Unit struct at:         0x0d869500      List head at:               0x0d869508
Next list head:         0x0d869208      Previous list head:         0x0d869820

Parent port at:         0x0d869800      SCSI dev struct at:         0x0e9f9e00
```

31-bit Experiences

- Vanilla kernel not sufficient:
  - fdisk partitioning “forgotten”
  - Problems with mke2fs:

```
daev005:/usr/src/linux/drivers/s390/scsi # mke2fs
/dev/sda2
mke2fs 1.19, 13-Jul-2000 for EXT2 FS 0.5b, 95/08/09
mke2fs: No such device or address while trying to
determine filesystem size
```

- Required reconfiguration:
  - `File Systems->Partition Types->MSDOS`

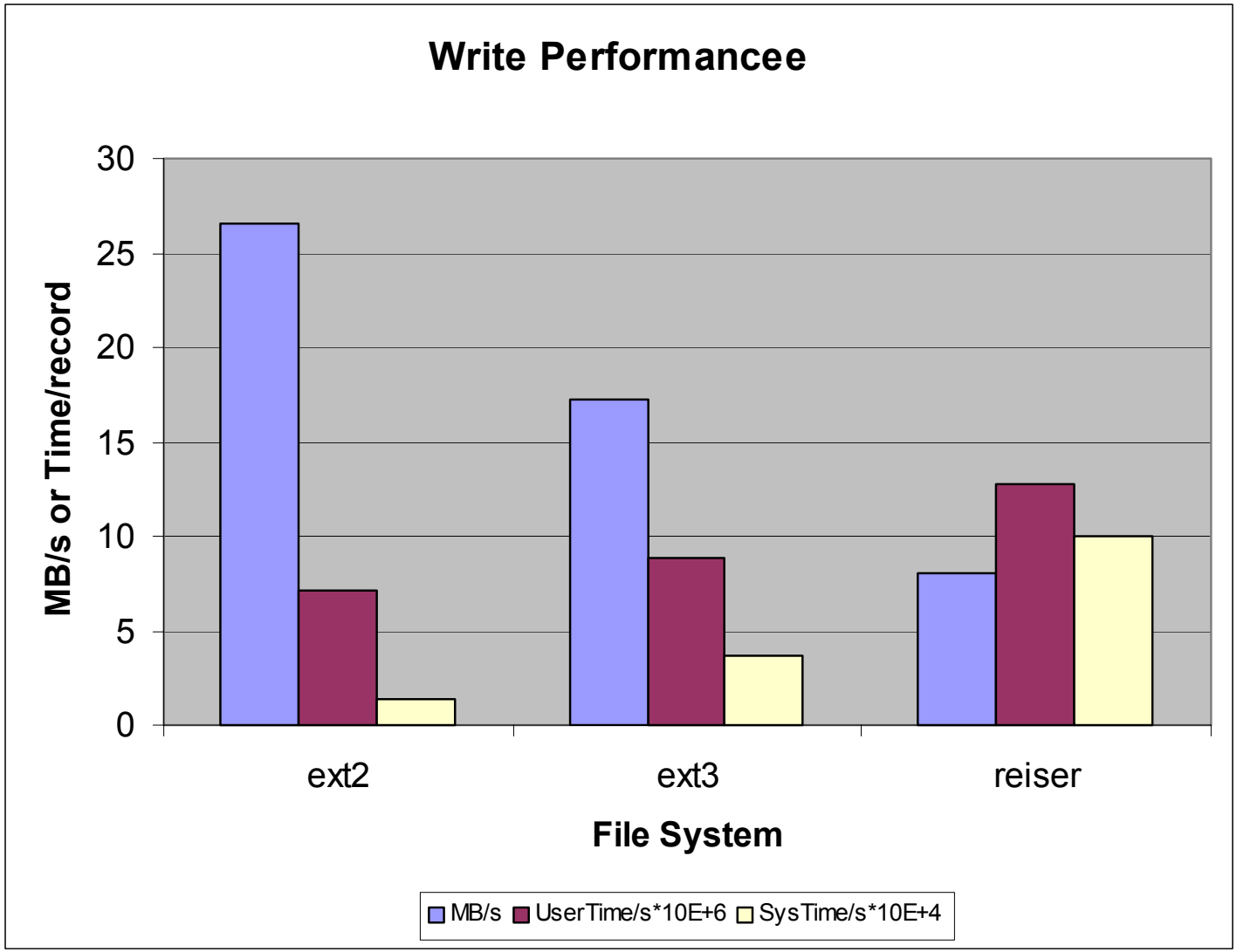
31-bit Experiences

- Product testing:
  - Adabas databases
    - 100MB data files
  - AQA tables (SQL access to Adabas)
  - All worked as expected

31-bit Experiences

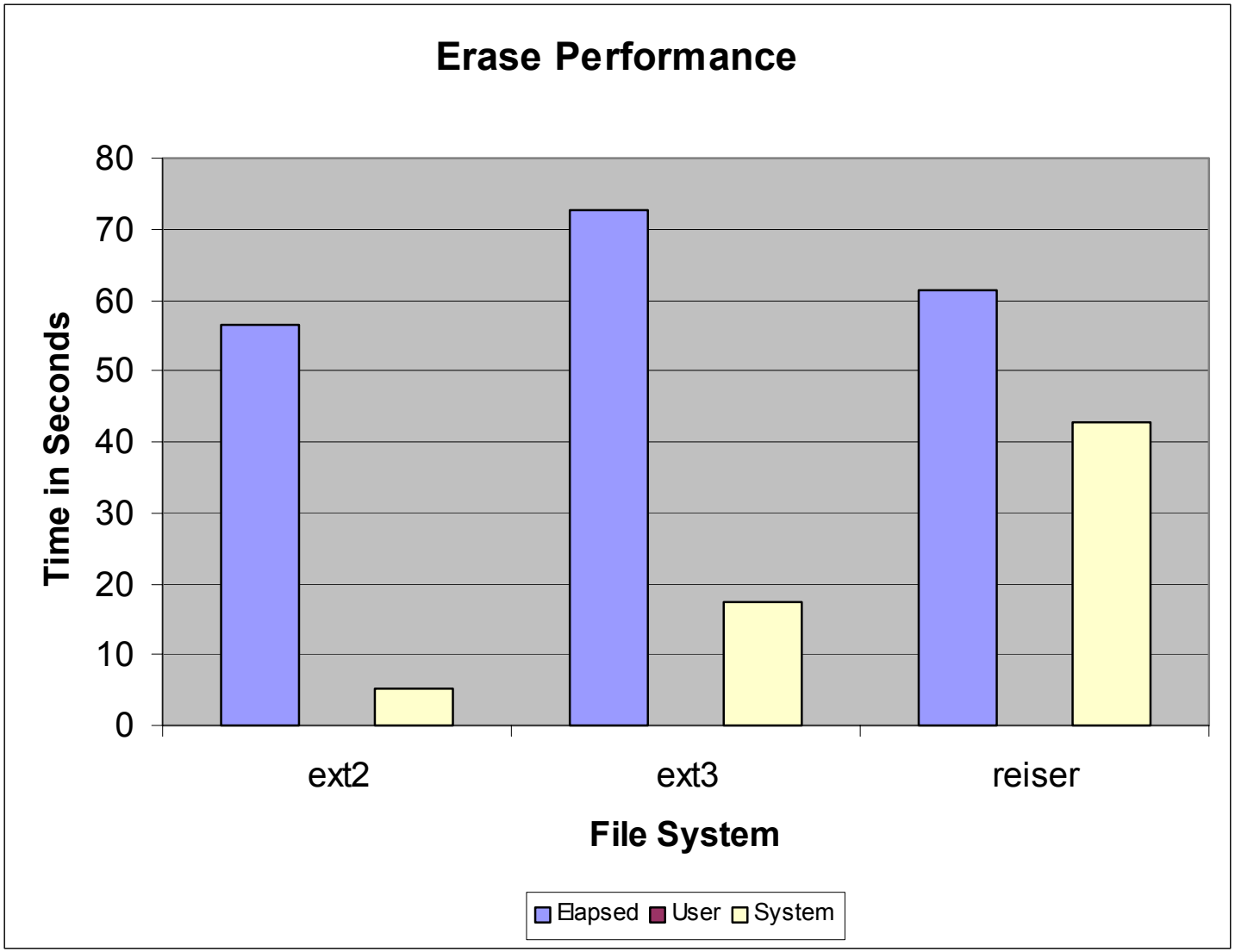
- Simplistic benchmarking
  - Used dd to exercise disk writes
  - Changed the underlying file system
    - ext2
    - ext3
    - reiser
  - Uncontrolled environment & unscientific methodology
    - CPUs shared with other LPARs
    - LPAR has low weighting
  - Results are indicative only

31-bit Experiences




```
dd if=/dev/zero of=/FS/scsi03/dummy.file bs=1024 count=43352000
```

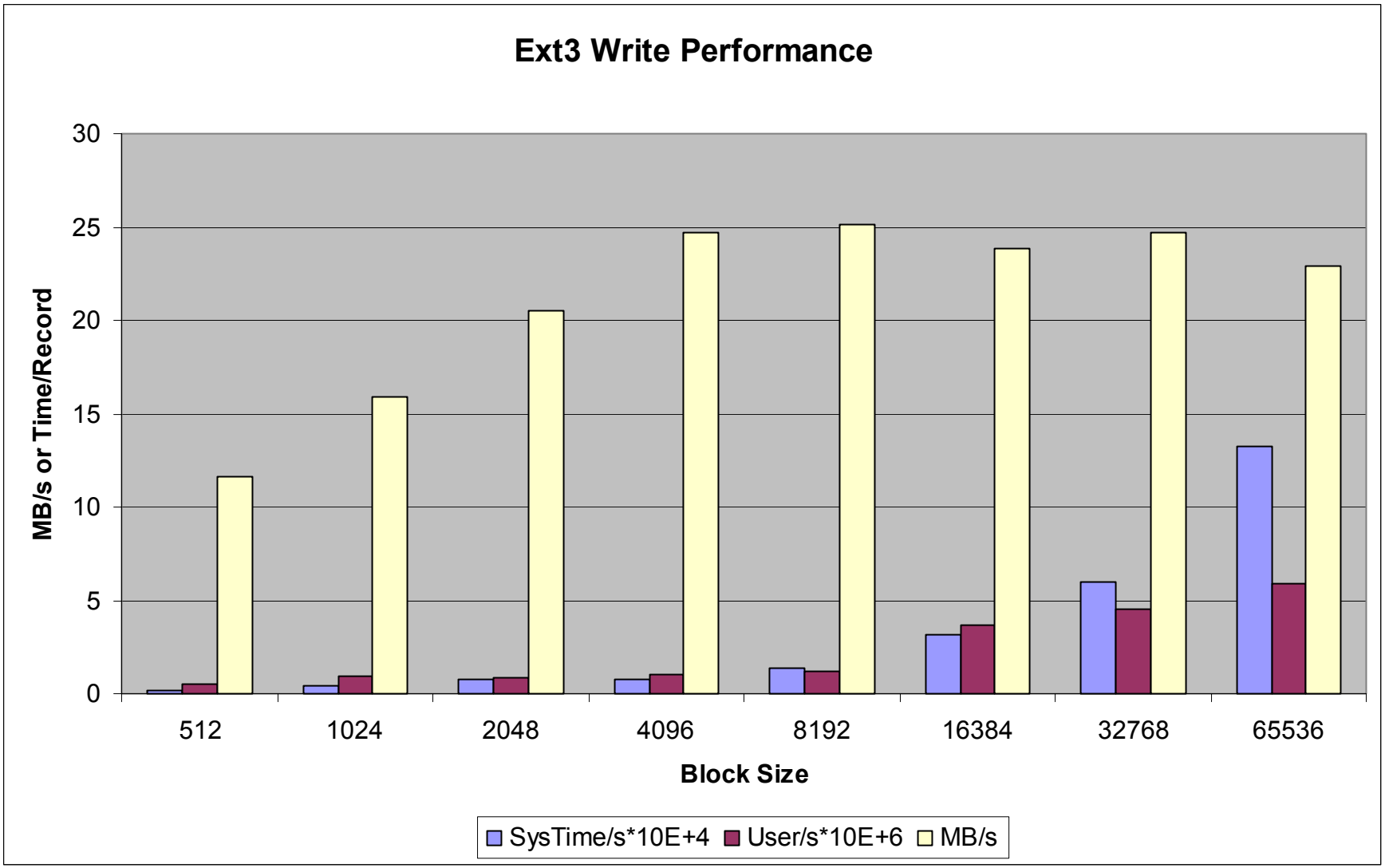
31-bit Experiences



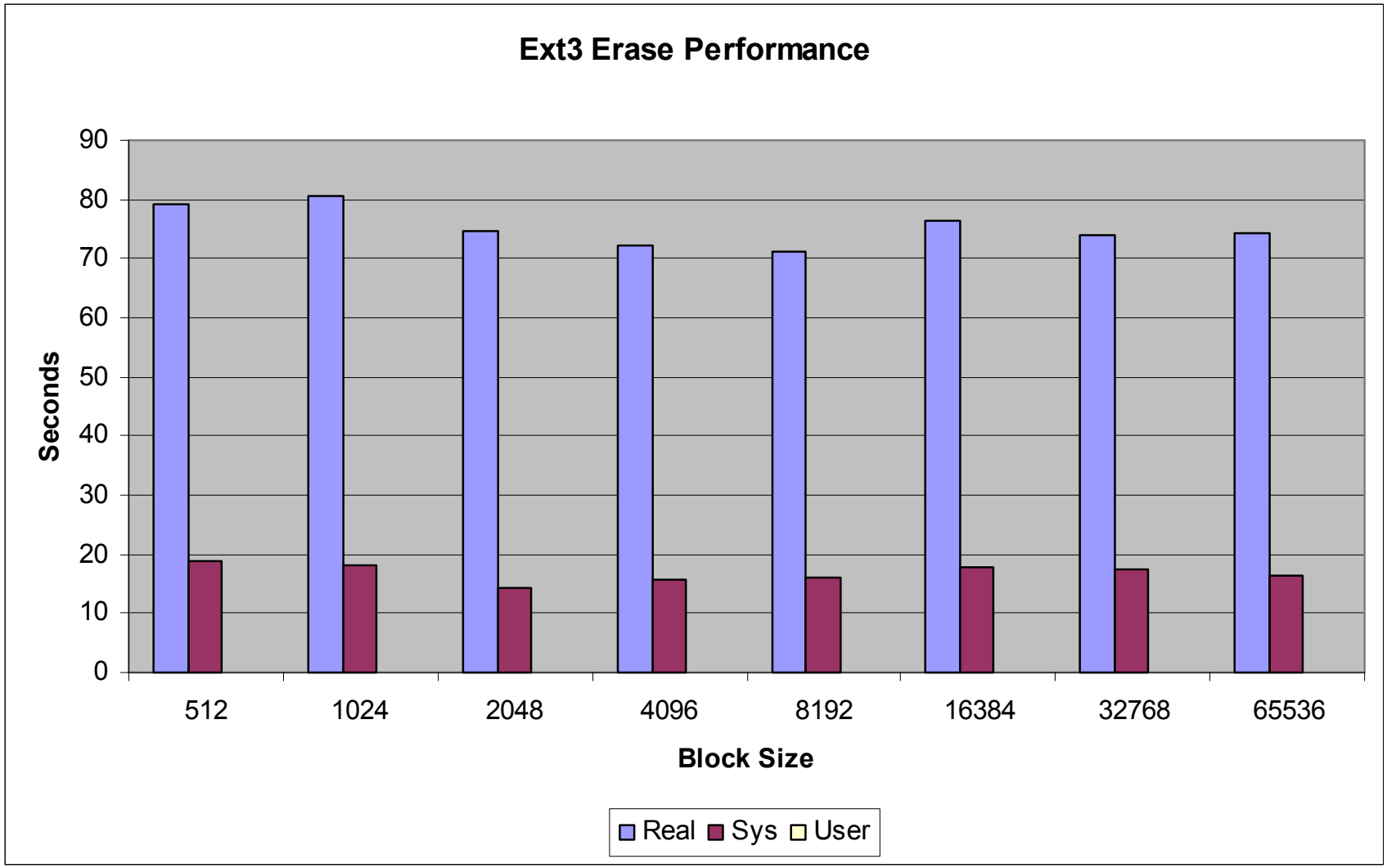
64-bit Experiences

- Product Testing
  - Adabas & AQA as per 31-bit
  - Included Natural
  - All worked as expected
- Similar transfer rate found when doing simplistic “dd” test

64-bit Experiences



64-bit Experiences



Future Work

- Connection to EMC devices
- Exercising multi-pathing
- Testing copy services
  - Can’t be done from Linux
  - Use the web interface to ESS