Linux for zSeries

Early Experiences with 64-bit Linux

Agenda

- z/Architecture Overview
- Linux implementation for z/Architecture
- ABI changes
- Early experiences with ThinkBlue64
- Early experiences with SuSE system
- Early experiences with Redhat

Linux for zSeries

z/Architecture Overview

z/Architecture Overview

- z/Architecture is the next step in the evolution from the System/360 to the System/370, S/370-XA, ESA/370, and ESA/390.
- z/Architecture includes all of the facilities of ESA/390 except for the asynchronous-pageout, asynchronous-data-mover, program-call-fast, and vector facilities.

z/Architecture Overview

- Four key features of z/Architecture include:
  - It is a full 64-bit architecture that provides for 24, 31 and 64-bit coexistence.
  - Intelligent Resource Director—Provides for an exclusive way to intelligently direct the processor and I/O resources to priority workloads running within the set of clustered LPARs.
  - HiperSockets—An internal facility for z/Architecture that permits a TCP/IP network to be established between LPARs.
  - License Manager Enablement—The z/Architecture includes capabilities that enable IBM's License Manager to run on z/OS and z900. This capability, when combined with HiperSockets, creates an '*n*-tier' environment for e-business applications within a z900.

z/Architecture Overview

- 64 bit PSW
  - Bit 12 – ‘0’ specifies z/Architecture
- 64 bit control registers
- 16 IEEE/HFP registers
  - No need for software emulation

z/Architecture Overview

- 64 bit general registers
  - Can be operated upon as 64 or 32 bit entities

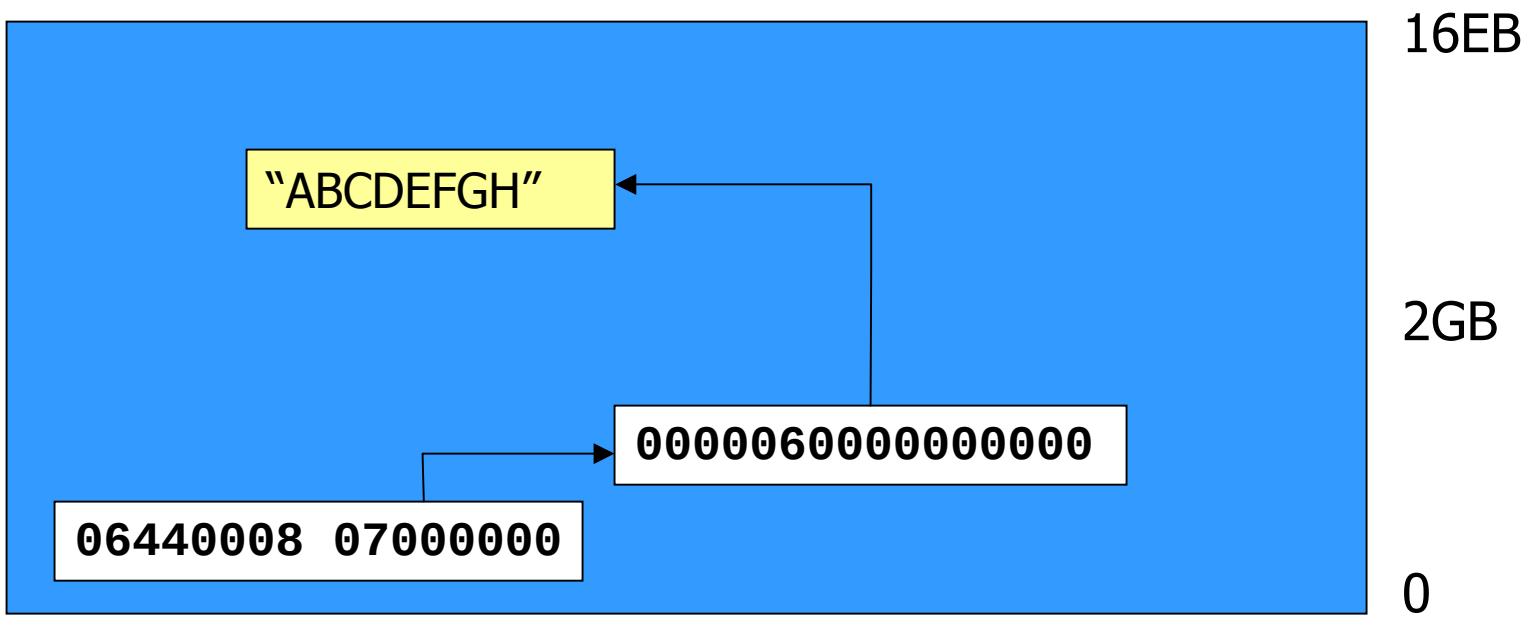
```
#include <stdio.h>
int main(int argc, char **argv)
{
 union {  long x;  int  y[2]; } longvar;

   longvar.x = -1;
   printf("%08X %08X %ld\n",longvar.y[0],longvar.y[1],longvar.x);
   __asm__  __volatile__ ("slr %0,%0" : "+d" (longvar.x) : : "cc");
   printf("%08X %08X %ld\n",longvar.y[0],longvar.y[1],longvar.x);
   __asm__ __volatile__ ("slgr %0,%0" : "+d" (longvar.x) : : "cc");
   printf("%08X %08X %ld\n",longvar.y[0],longvar.y[1],longvar.x);
}

FFFFFFFF FFFFFFFF -1
FFFFFFFF 00000000 -4294967296
00000000 00000000 0
```

z/Architecture Overview

- 64 bit addressing
  - 24 bit support
  - 31 bit support
  - Up to 3 levels of “Region Tables” to give:
    - 42, 53, 64 bit addressing
  - Use **sam*xx*** instruction to switch addressing modes
- New term:
  - >16MB = “above-the-line”
  - >2GB = “above-the-bar”

z/Architecture Overview

- 32 bit Access Registers
- CCWs still only use 31 bit address fields
  - IDAL used for “above-the-bar”



z/Architecture Overview

- Prefix page now 8KB
- LOTS of new instructions
  - 64 bit versions of 32 bit ops: LG (load) = L (load)
  - Instructions to manipulate 32 bit entities: LGFR
  - Some new compiler-friendly: RLL/RLLG; ALC/ALCG
  - Address mode related: SAM24/31/64; TAM
  - Unicode support: CUUTF; TRE **
  - Enhanced relative branching: +/- 2GB branches

z/Architecture Overview

- New old/new PSW locations

```
EXT 1004   130 OLD 07060001 80000000 00000000 00015F1A
           1B0 NEW 04000001 80000000 00000000 00014D32
SVC 008E   140 OLD 0701C001 80000000 00000200 002618A6
           1C0 NEW 04000001 80000000 00000000 0001406C
PRG 0004   150 OLD 07004001 80000000 00000000 00087C7A
           1D0 NEW 04000001 80000000 00000000 00014AD6
MCH 0000   160 OLD 00000000 00000000 00000000 00000000
           1E0 NEW 04000001 80000000 00000000 00014DEA
I/O 0004   170 OLD 07060001 80000000 00000000 00015F1A
           1F0 NEW 04000001 80000000 00000000 00014C3A
```

z/Architecture Overview

- Implemented on:
  - z900 (aka Freeway) processors
  - Hercules
    - No SIGA/SERVC - proprietary
  - Flex/ES (or should be in the future)
- Supported by:
  - z/VM
  - OS/390
  - Linux for zSeries

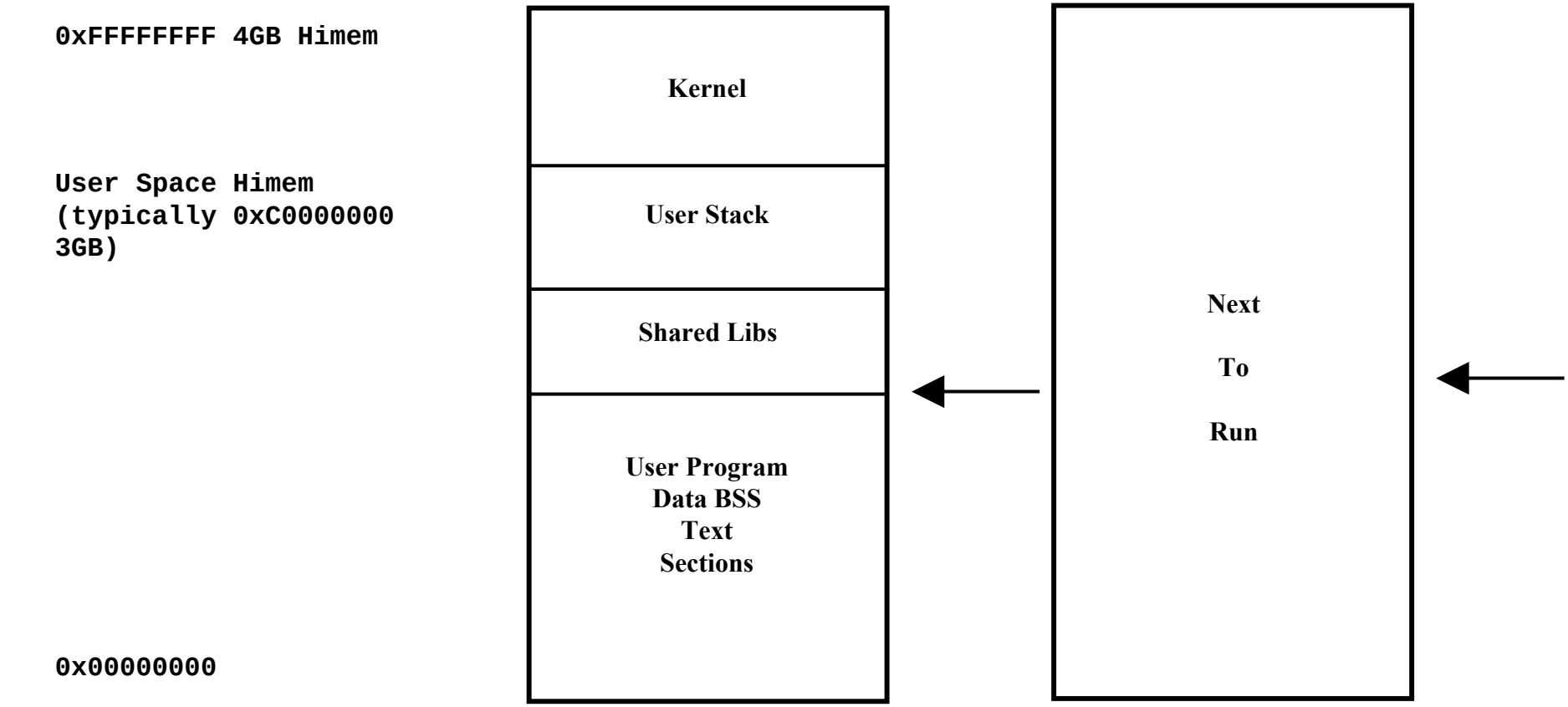
Linux for zSeries

Linux Implementation for z/Architecture

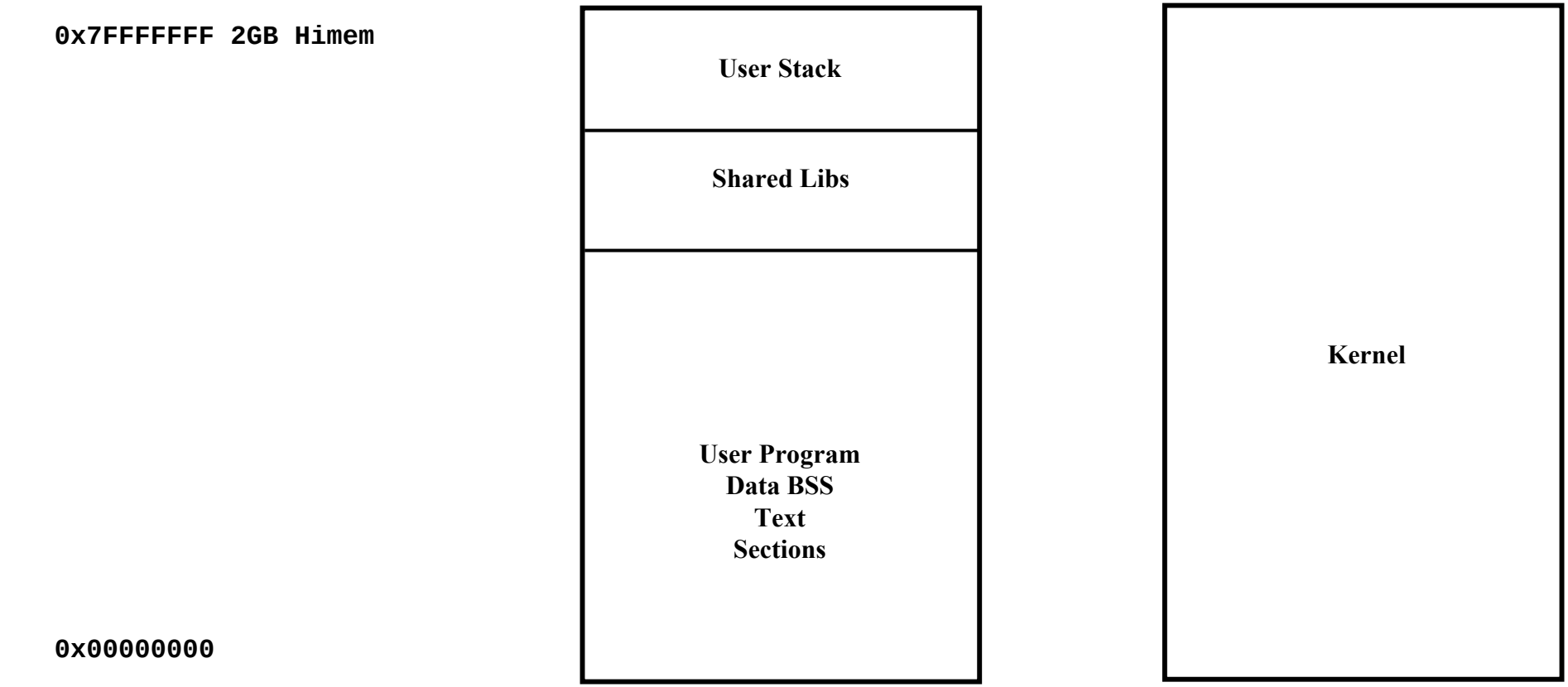
Linux for zSeries

- Based on 2.4 kernel
- Requires:
  - binutils
  - gcc
  - glibc
- Boots in 31 bit mode
- Switches to 64 bit mode fairly quickly

Linux – Intel Address Spaces

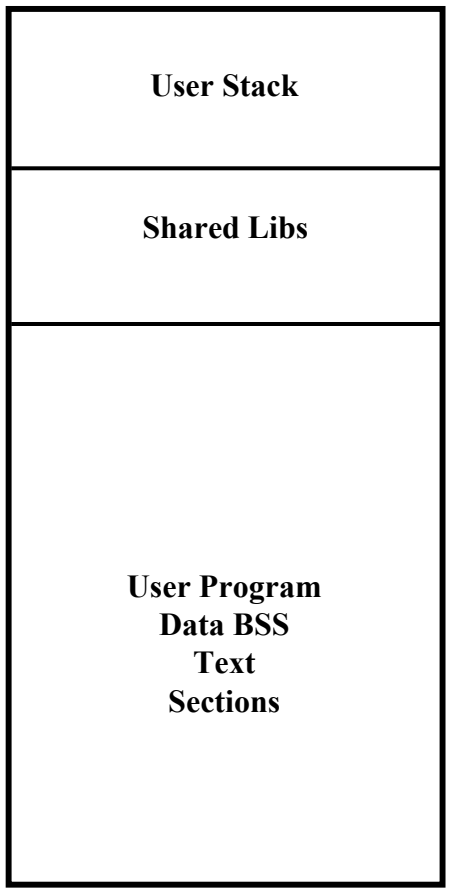


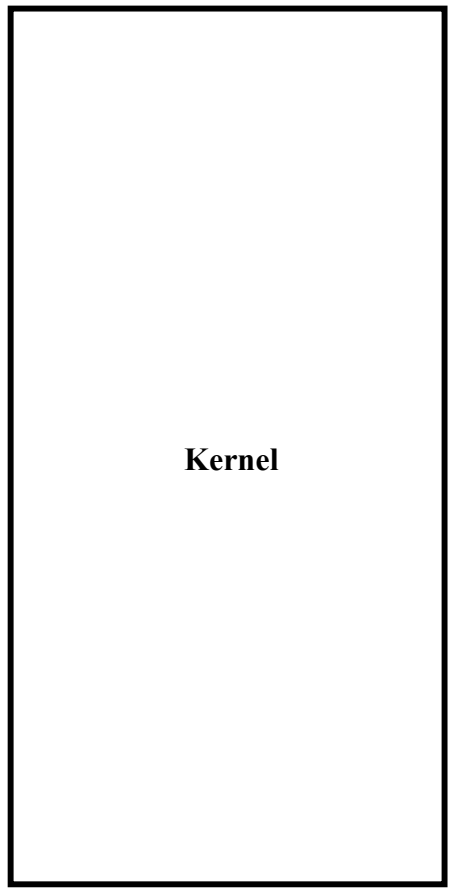
Linux – S/390 Address Spaces



Linux – zSeries Address Spaces

0x3FFFFFFFFF 4TB
Himem



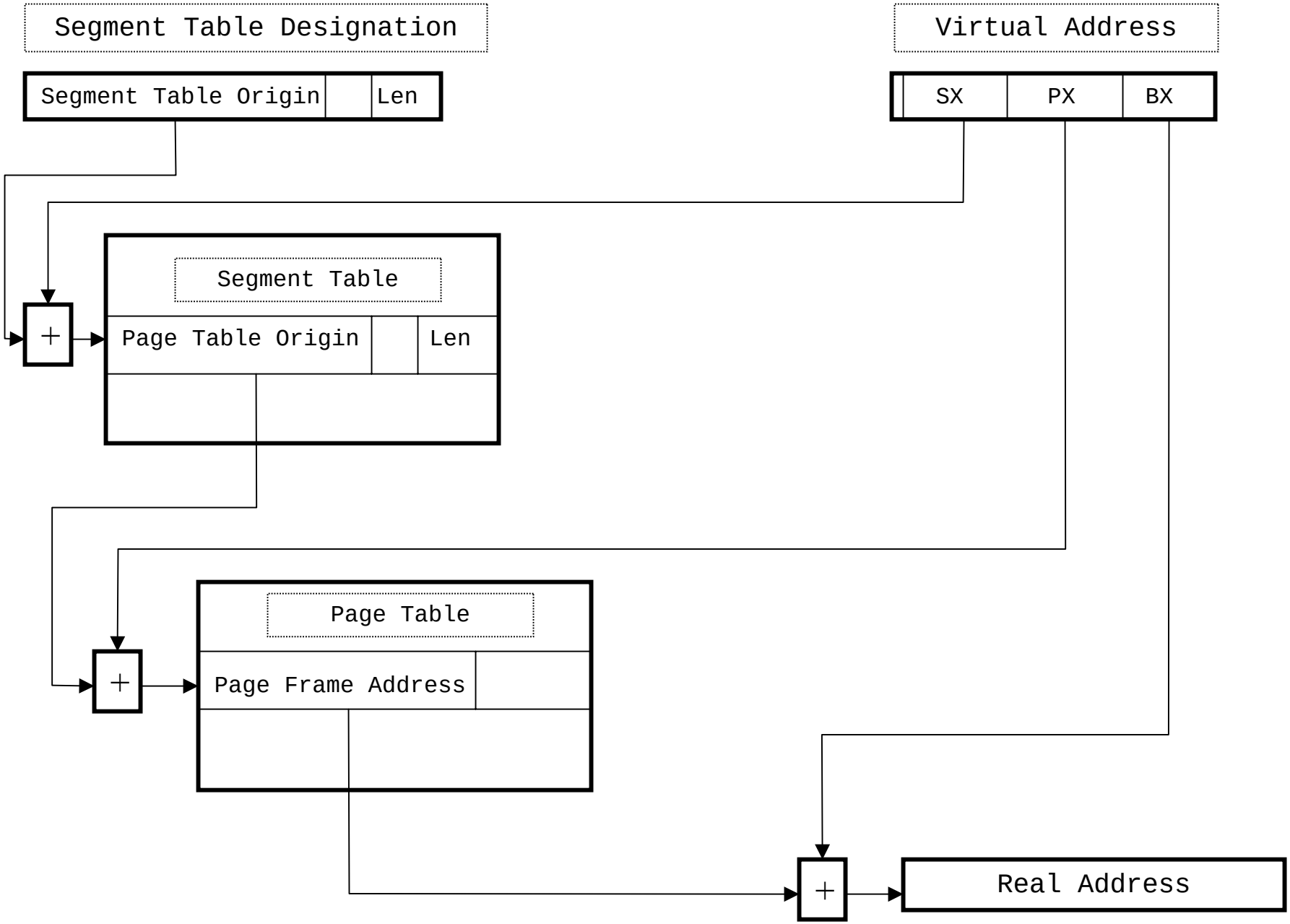


0x00000000

SHARE
Technology · Connections · Results

- A virtual address on S/390 is made up of 3 parts:

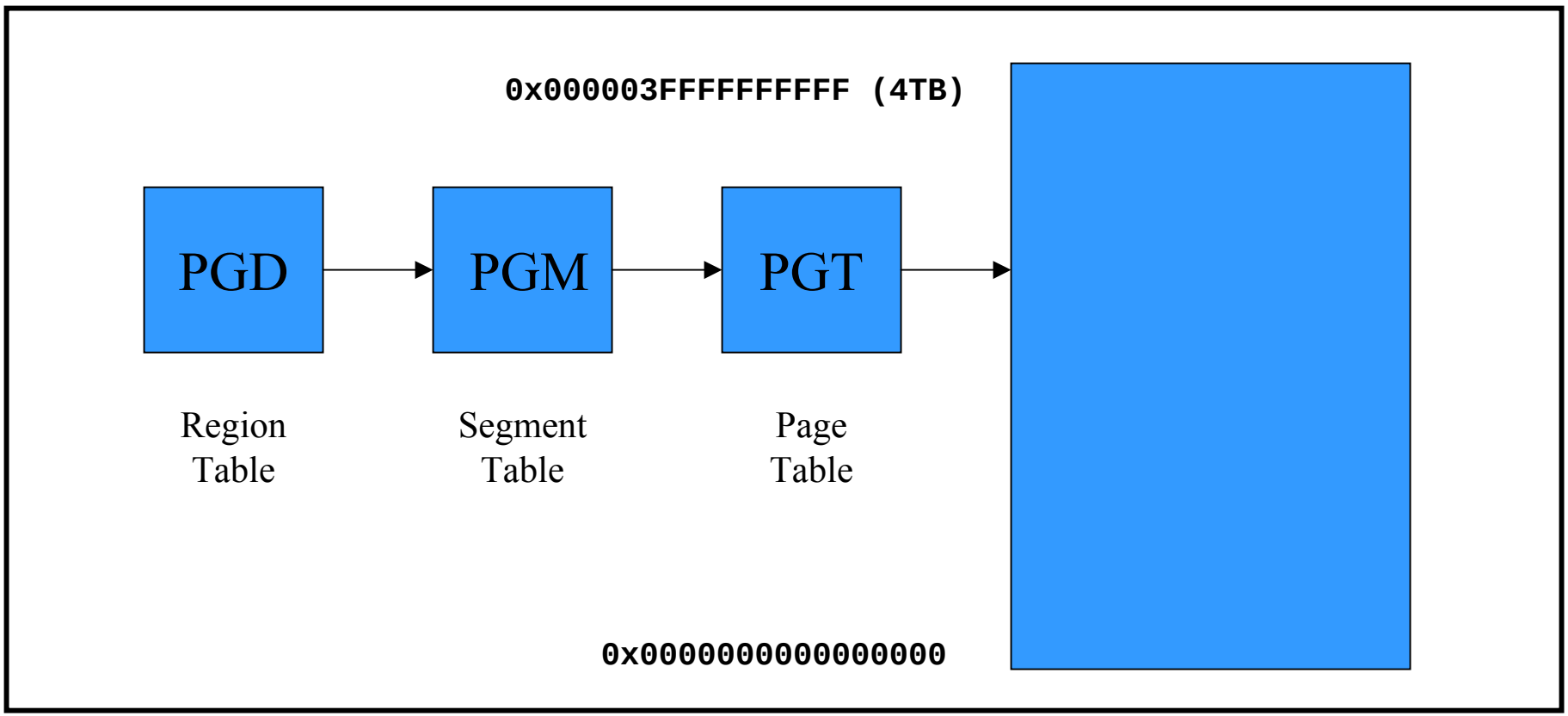
- On z/Architecture in Linux we currently make up an address from 4 parts:


Segment Table Designation
Virtual Address
Segment Table Origin
Len
SX
PX
BX
Segment Table
+
Page Table Origin
Len
Page Table
+
Page Frame Address
+
Real Address

Linux for zSeries

- 64-bit
- 4TB address spaces
  - 1 Region Table
  - Segment Table
  - Page Table
- 31-bit compatibility mode
  - Existing apps will run
  - Provided they can find their libraries!
  - Problems with some APIs (e.g. **`shmctl()`**)
  - Work done for co-existence: /lib64 & /lib

zArchitecture Address Spaces



Address Spaces

- Kernel runs in Primary Space mode
- User programs run in Home Space mode
- Copy to/from user just a MVC(L/E) in Access Register mode with AR set for kernel/user address spaces
- Compare this to some of the other elaborate schemes used

Address Space Usage

```
0000000080000000-0000000080008000 r-xp 0000000000000000 5e:01 207901 /bin/more
0000000080008000-0000000080009000 rw-p 0000000000007000 5e:01 207901 /bin/more
0000000080009000-000000008000d000 rwxp 0000000000000000 00:00 0
0000020000000000-000002000001b000 r-xp 0000000000000000 5e:01 223562 /lib/ld-2.2.2.so
000002000001b000-000002000001d000 rw-p 000000000001a000 5e:01 223562 /lib/ld-2.2.2.so
000002000001d000-000002000001f000 rw-p 0000000000000000 00:00 0
0000020000024000-0000020000028000 r-xp 0000000000000000 5e:01 223625 /lib/libtermcap.so.2.0.8
0000020000028000-0000020000029000 rw-p 0000000000003000 5e:01 223625 /lib/libtermcap.so.2.0.8
0000020000029000-0000020000170000 r-xp 0000000000000000 5e:01 223567 /lib/libc-2.2.2.so
0000020000170000-0000020000179000 rw-p 0000000000146000 5e:01 223567 /lib/libc-2.2.2.so
0000020000179000-000002000017f000 rw-p 0000000000000000 00:00 0
000003ffffffd000-0000040000000000 rwxp fffffffffffe000 00:00 0
```

New Device Drivers

- Tape
  - 3490
  - Character and block
- 3270
  - Console
  - Standard terminal
- Cisco Routers
- Hipersockets
- FCP (SCSI)

Device Drivers

- CCWs must live “below-the-bar”
- Kernel supports memory requests for under the bar storage (**`GFP_DMA`**)
- Device drivers build CCW programs in this storage
- IDALs used to address “above-the-bar” storage

Linux for zSeries

ABI Changes

Application Binary Interface

- The Executable and Linkage Format Application Binary Interface (or ELF ABI), defines a system interface for compiled application programs. Its purpose is to establish a standard binary interface for application programs on LINUX for S/390 systems.

Application Binary Interface

- Defines (amongst other things):
  - Data formats
  - Byte layouts
  - Stack layouts
  - Process initialization
  - Register conventions
  - Routine linkage
  - Parameter passing
  - Returning results

Application Binary Interface

- Changes required for 64-bit support
  - Stack layouts
  - Routine prologues
  - Register conventions
  - Parameter passing
- Transparent for compiled applications
- Need to understand for such things as “FFI” or “JNI” or writing compilers

Stack Frame Layouts

Offset	Offset	Description
0	0	Back chain (a 0 here signifies end of back chain)
4	8	EOS (end of stack, not used on Linux for S390)
8	16	Glue used in other linkage formats
12	24	Glue used in other linkage formats
16	32	Scratch area
20	40	Scratch area
24-63	48-127	GPR register save area
64-79	128-159	FPR4 & FPR6 save area
96	160	Outgoing args (length x)
96+x	160+x	Possible stack alignment
96+x+y	160+x+y	alloca space of caller (if used)
96+x+y+z	160+x+y+z	Automatics of caller (if used)

31 Bit Co-existence

- ELF header indicates executable as:
  - S/390
  - 31 bit/64 bit
- Dynamic executables contain information regarding location of shared libraries
- ld.so.1 or ld.64 resolves information in elf header

31 Bit Co-existence

- Use **`ldd`** command to show what libraries your executable requires
- 31 bit apps cannot use 64 bit libraries
- LD_LIBRARY_PATH environment variable overrides internal specification of executable
- Can be set up globally or per application
- Look out for 2.1.3 glibc & 2.4 kernel disparities

31 Bit Co-existence

- SuSE have /lib64 and /lib
- Apps migrated from 31-bit will find their libraries
- Programs built on 64-bit system will look in /lib64

Linux for zSeries

ThinkBlue64 –Early Experiences

ThinkBlue64

- Redhat-like distribution
- 7.1 now available
- Download from http://linux.zseries.org
- CDROM ISO image available
- 749 RPMS
- Starter system:
  - Kernel (tape or VM reader)
  - Initial RAMDISK (tape or VM reader)
  - Parameter file

ThinkBlue64

- glibc-2.2
- Kernel 2.4.3 (2.4.5)
- Hard IRQ bug in **`ctcmain`**
- **`skb_buff`** problem with ctc
- Heaps of RPMS!

ThinkBlue64

- Starting (using NFS):
  - Mount CDROM on another Linux system:

```
mount -o loop ThinkBlue64-disc1.iso /mnt/cdrom
```

  - Add **`/mnt/cdrom`** to **`/etc/exports`** and restart NFS server

```
# See exports(5) for a description.
# This file contains a list of directories exported to other computers
# It is used by rpc.nfsd and rpc.mountd.
/mnt/cdrom      10.20.45.7(rw;no_root_squash)
```

  - **`/etc/rc.d/nfsserver restart`**

ThinkBlue64

- Starting
  - New option for 7.1
  - Mount CDROM on another Linux image
  - Use FTP option

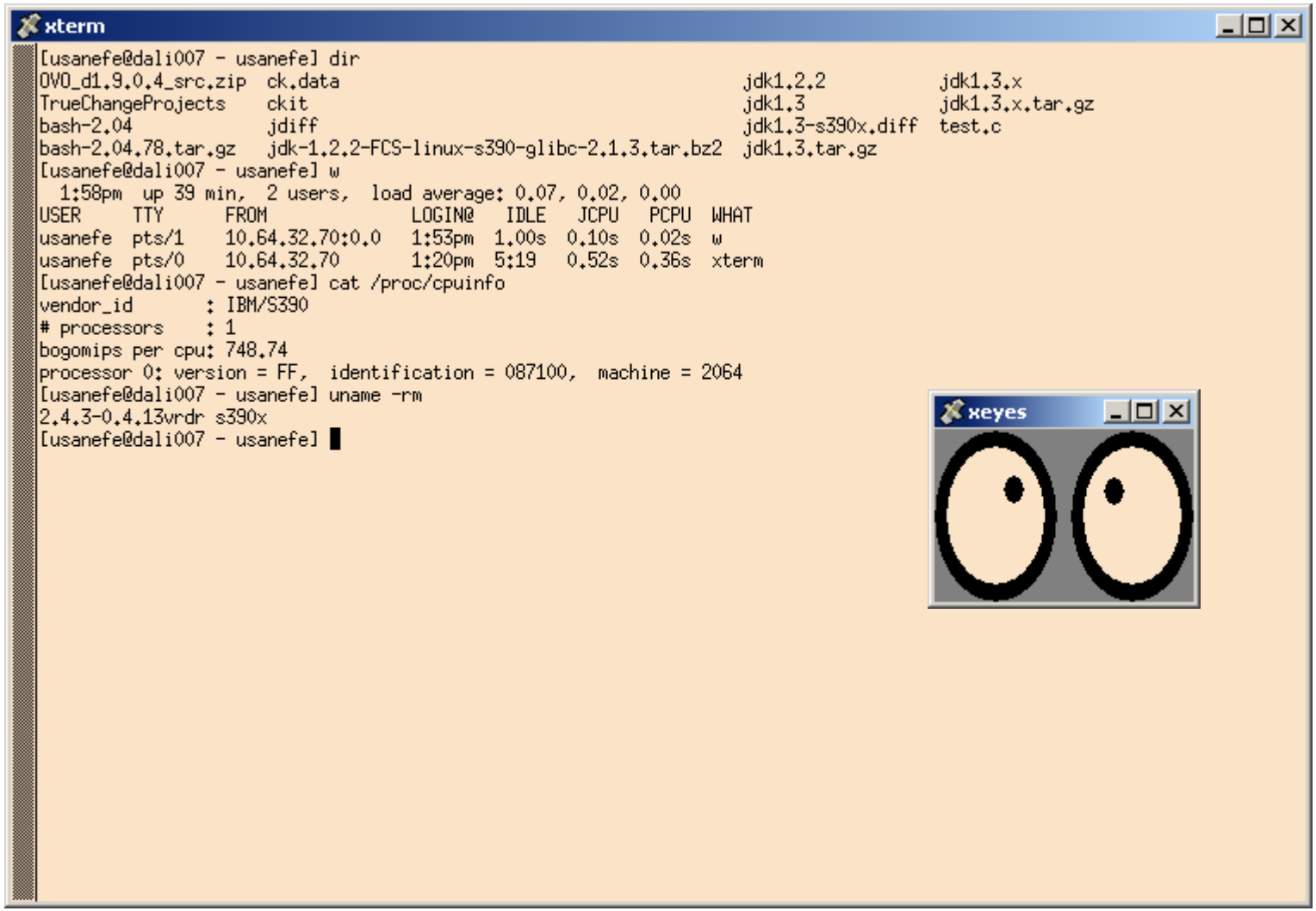
ThinkBlue64

- Upload starter components
- Punch to and boot from reader
- Answer questions:
  - IP connectivity
  - NFS server location
- Telnet to starter system
- Begin install of RPMS: **`./install`**

ThinkBlue64

- Three panels of questions:
  - Disks to use and mount points: No swap
  - NFS server containing RPMS
  - [Repeat answers on IP addresses etc.]
  - Install begins
- Install process runs **`zilo`**
- Now boot from disk

ThinkBlue64



ThinkBlue64

- Current work:
  - bash2 – fixed in 7.1
    - Problem with signal handling: Union of pointer and int
  - Regina ported
  - JDK 1.3 port ready for certification testing
    - Porting invokeNative_s390.S
    - Instructions: **`sllg r1,r1,2`** versus **`sll r1,2`**
  - Assessing requirements & efforts for SAG products

JDK 1.3.0

```
[usanefe@dali007 - usanefe] java -version
java version "1.3.0_02"
Java(TM) 2 Runtime Environment, Standard Edition (build Blackdown-
1.3.0_02-FCS)
Classic VM (build Blackdown-1.3.0_02-FCS, native threads, nojit)
[usanefe@dali007 - usanefe] file
/usr/local/j2sdk/bin/s390x/native_threads/java
/usr/local/j2sdk/bin/s390x/native_threads/java: ELF 64-bit MSB
executable, version 1, dynamically linked (uses shared libs), not
stripped
```

ThinkBlue64

- Built glibc-2.2.3 – appears quite stable
  - Has make/swap-context APIs
  - Required for green-thread support of Java
- Built openMotif – appears to work
- Enhanced CPINT
  - 2.4 & 64-bit support
  - Ability to retrieve CP return code via **`ioctl()`**
  - Fixed a couple of bugs: passwords & buffer size

Early Experiences

64-bit SuSE System

SuSE System

- All externals/procedures as per SLES7
- 2.4.17+ kernel
- glibc 2.2.4+
- Hipersocket support
- Required “nopfault” on parmline
- Bug found in ucdsnmp
  - ssize_t versus int
- Worked perfectly with 8 CPUs and 3GB memory
- Problem with qdio driver - fixed

Some Problems – All Fixed

- X11 “funnies”
- **`pthread_cancel`** cleanup peculiarities
- signal handler recursion
- Support of **`SA_SIGINFO`**
- CTC buffersize set at 32K
  - **`skb_buff()`** failures
- **`pthread_create`** race condition
- **`pfault`** Ooopses (z/VM 4.2 fix required)

Things are changing fast…

- zfcp support
- gcc 3.1.1

Linux for zSeries

Redhat

Redhat

- 2.4.9+
- glibc-2.2.4-24
- Installed without a problem
- Configuration of hipersocket a bit of a task
- I’m Too used to YaST

Linux for zSeries

Miscellany

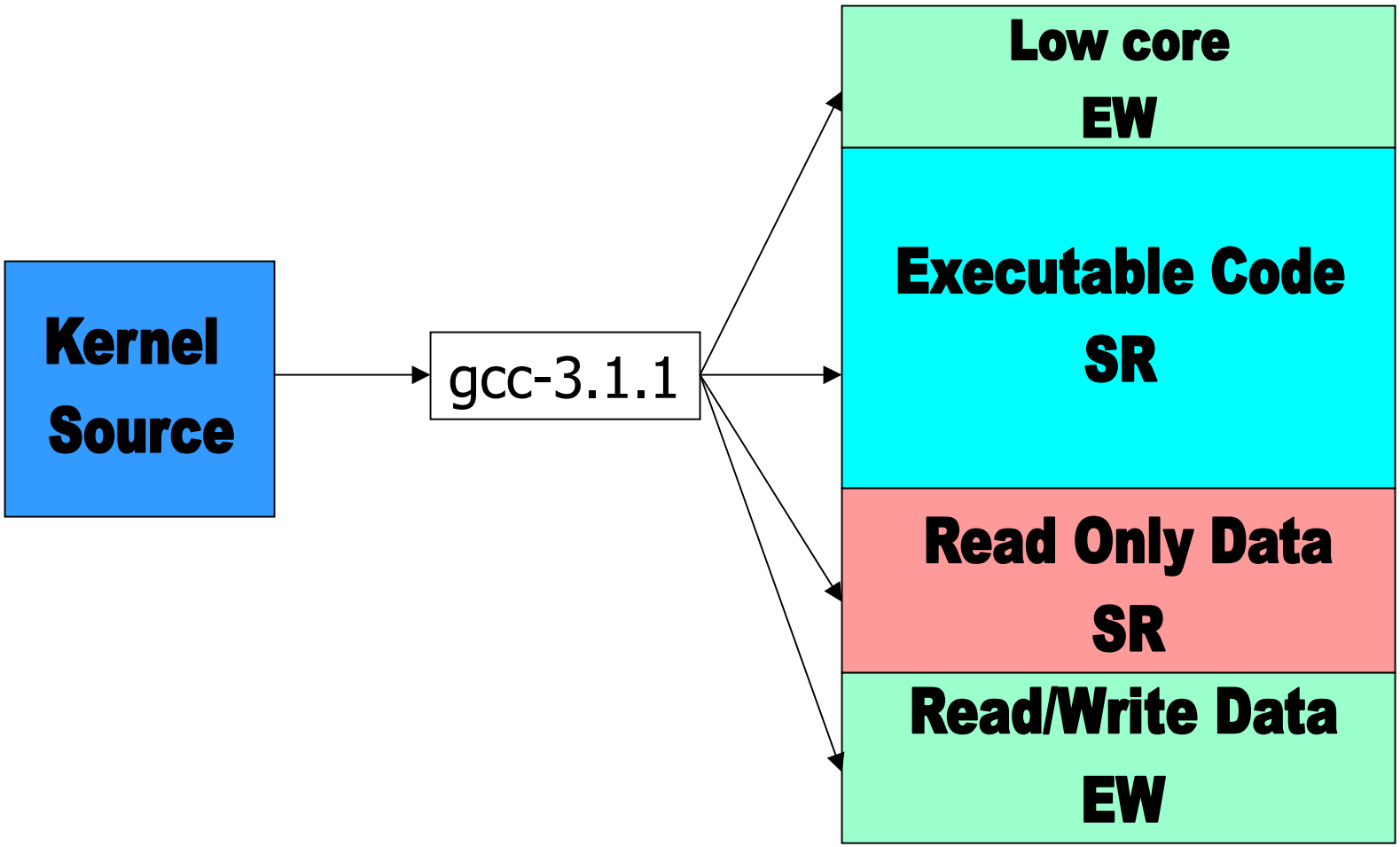
Shared Kernel

- Linux in a NSS (needs gcc-3.1.1)

```
+#ifdef CONFIG_SHARED_KERNEL
+       .org   0x100000
+#else
        .org   0x10800
+#endif
```

- Do a `make image` to avoid long wait caused by kernel disassembly

Shared Kernel



PFAULT Handling

```
+#ifdef CONFIG_PFAULT
+       if (MACHINE_IS_VM) {
+               /* request the 0x2603 external interrupt */
+               if (register_external_interrupt(0x2603, pfault_interrupt) != 0)
+                       panic("Couldn't request external interrupt 0x2603");
+               /*
+                * Try to get pfault pseudo page faults going.
+                */
+               if (pfault_init() != 0) {
+                       /* Tough luck, no pfault. */
+                       unregister_external_interrupt(0x2603,
+                                                     pfault_interrupt);
+               }
+       }
+#endif
```

Questions