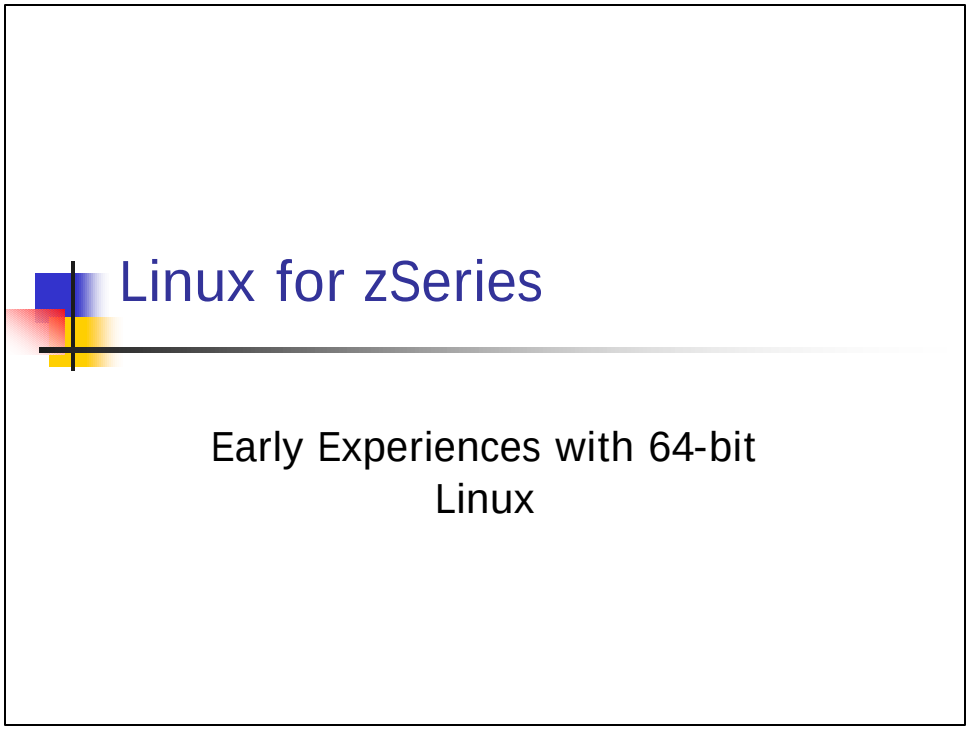
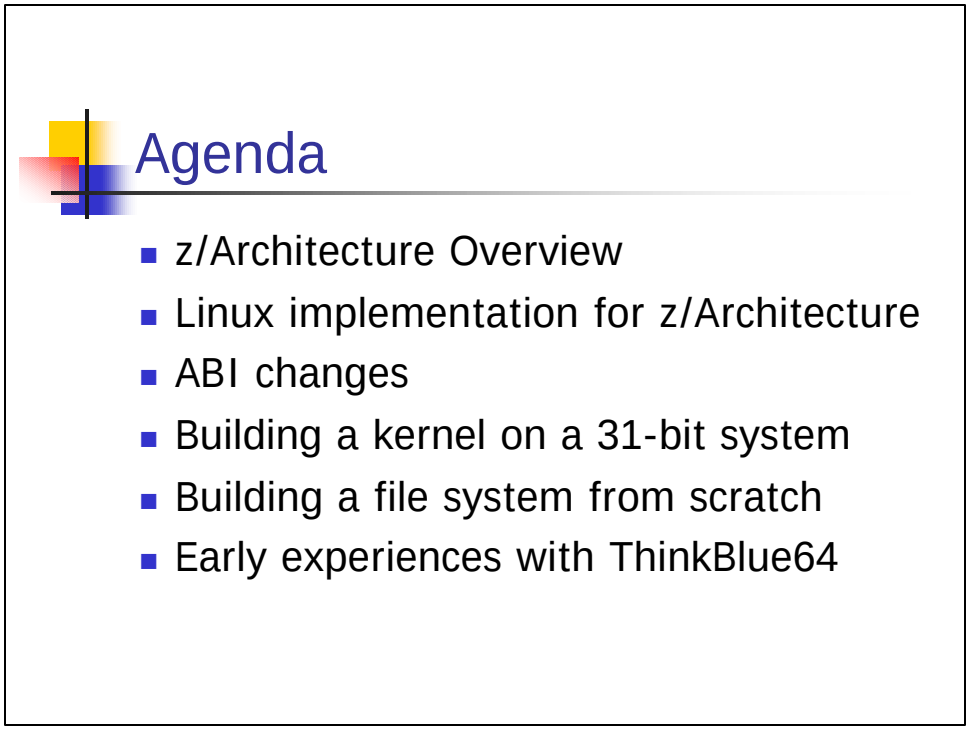
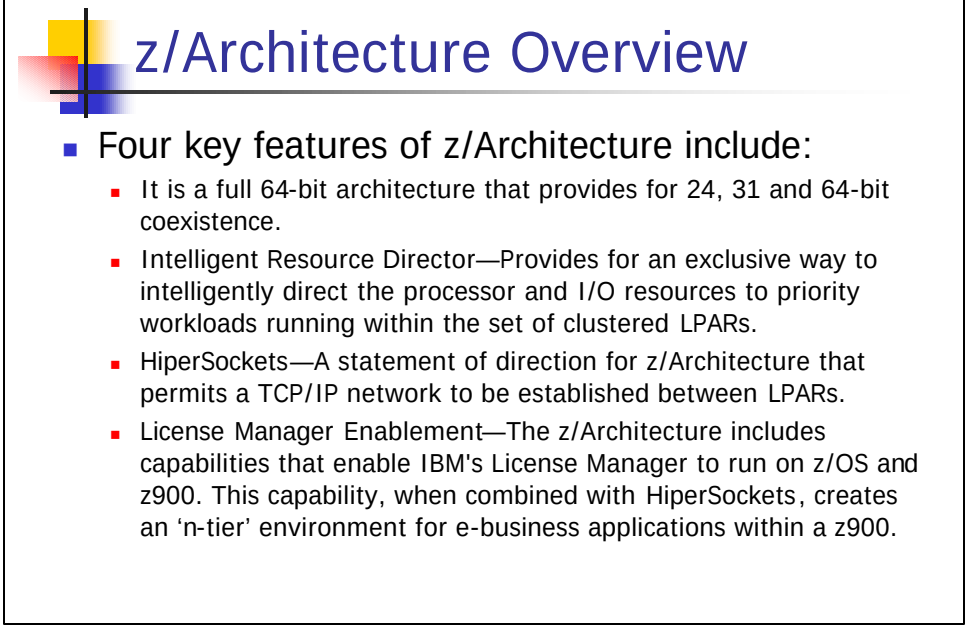
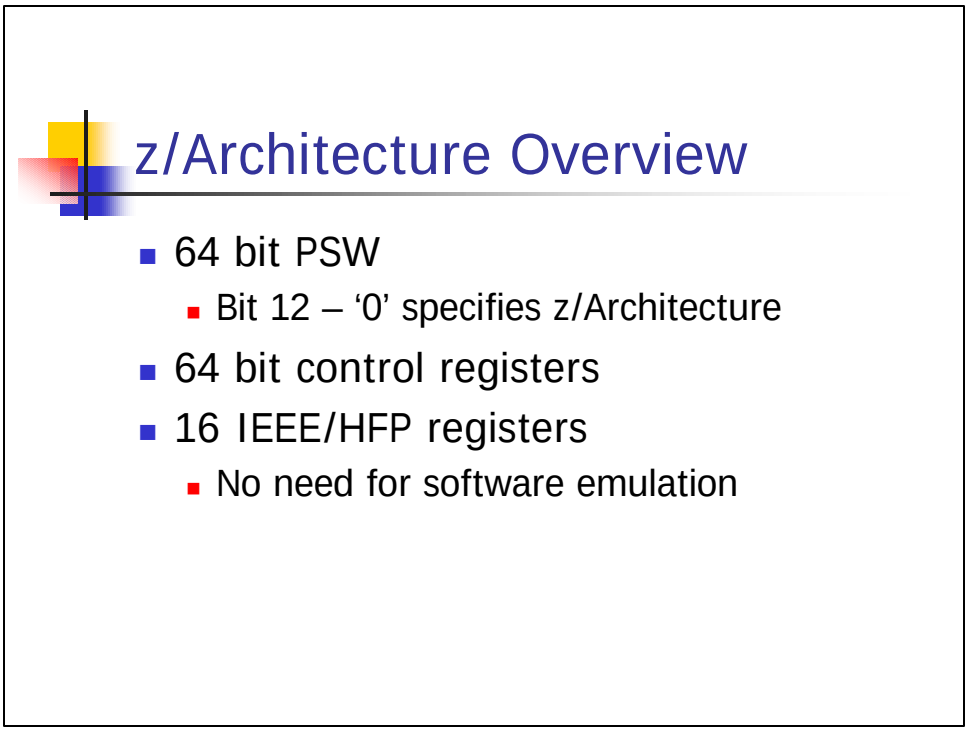



## z/Architecture Overview

- 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

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

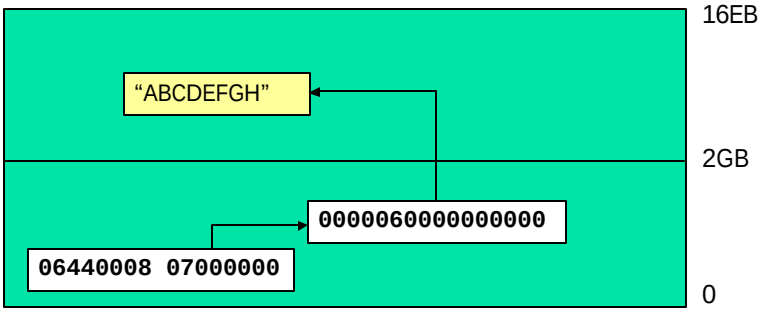
```
#include <stdio.h>
int main(int argc, char **argv)
{
 union {  long x;  int  y[2]; } longvar;

   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

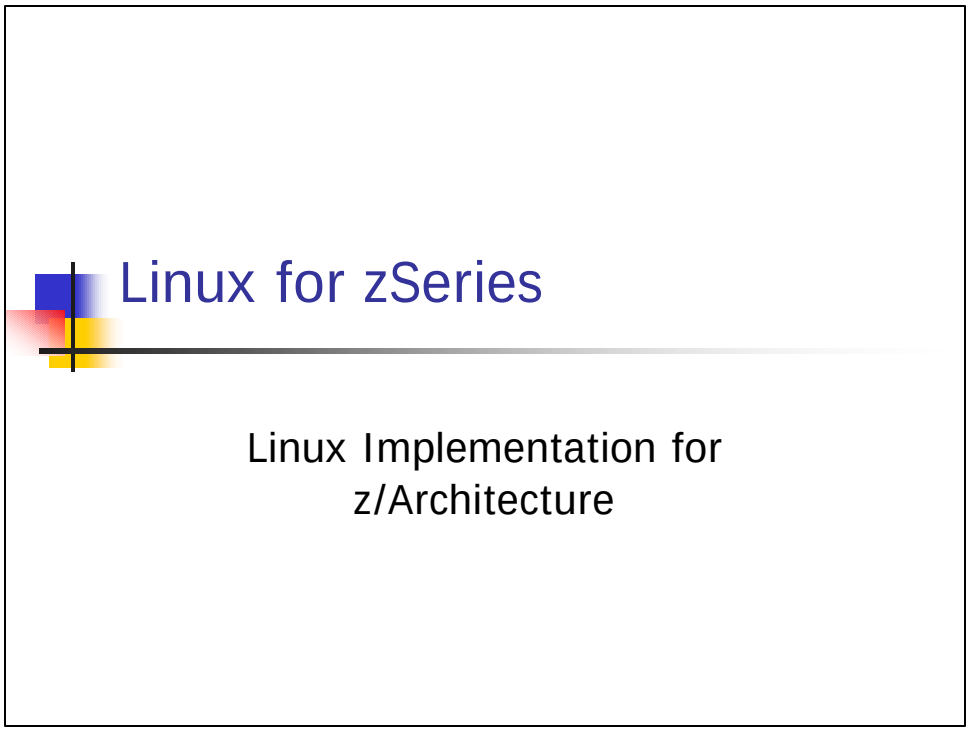
## z/Architecture Overview

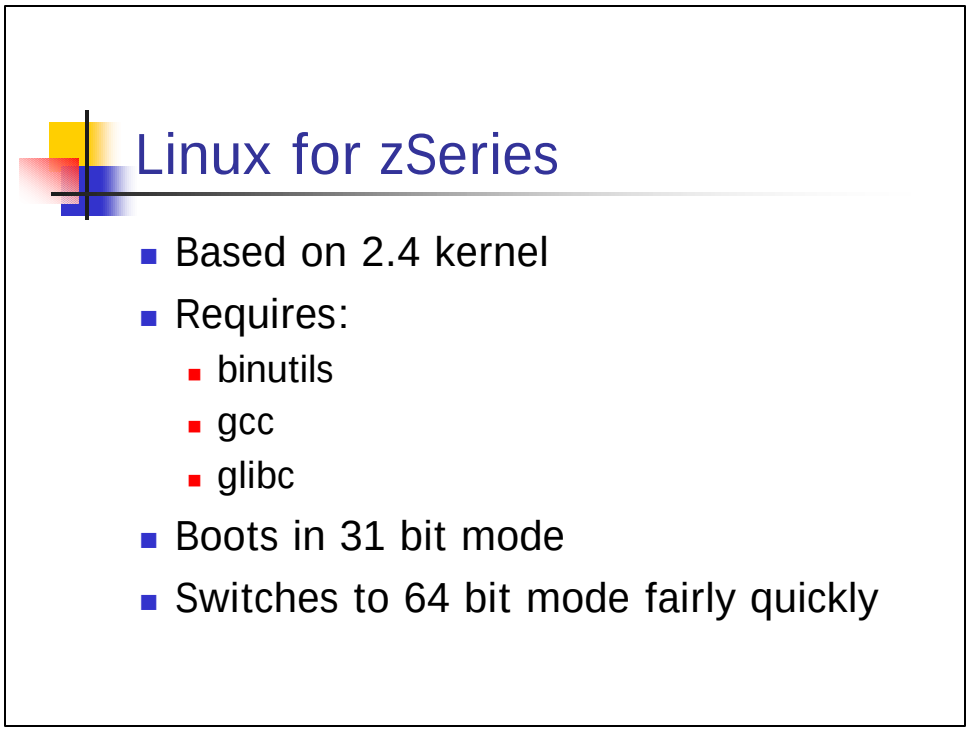
- New old/new PSW locations

```
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
```

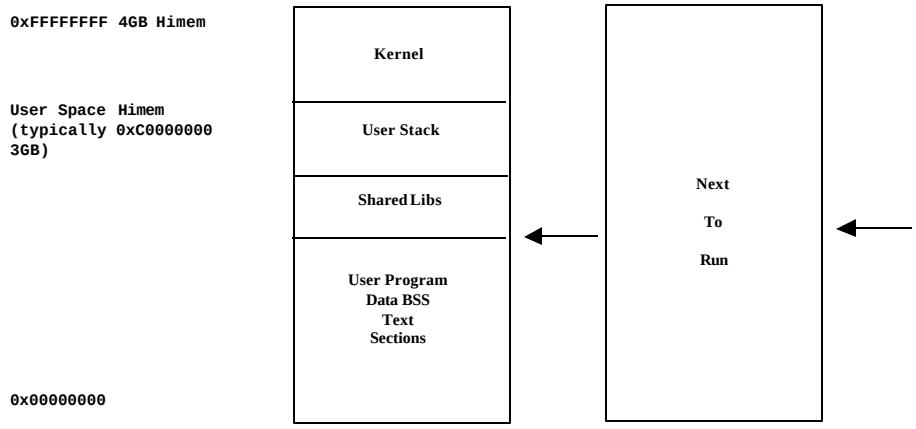
## z/Architecture Overview

- Implemented on:
  - z900 (aka Freeway) processors
  - Hercules
  - Flex/ES (or should be in the future)
- Supported by:
  - z/VM
  - OS/390
  - Linux for zSeries

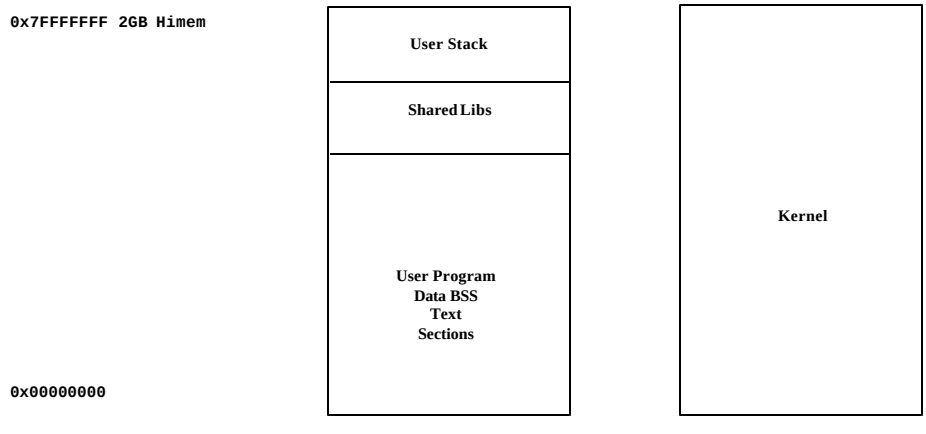


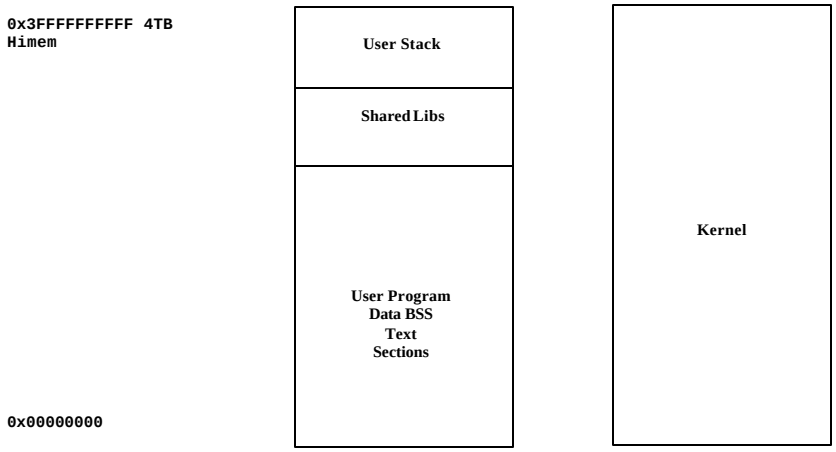
# Linux – Intel Address Spaces




# Linux – S/390 Address Spaces

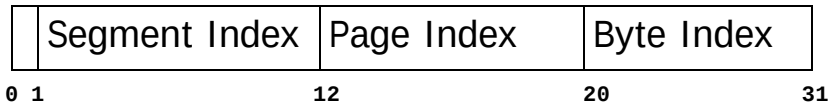


## Linux – zSeries Address Spaces

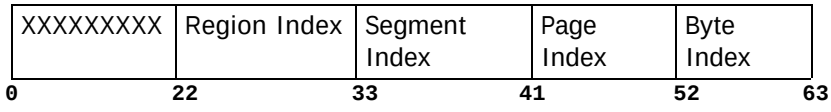


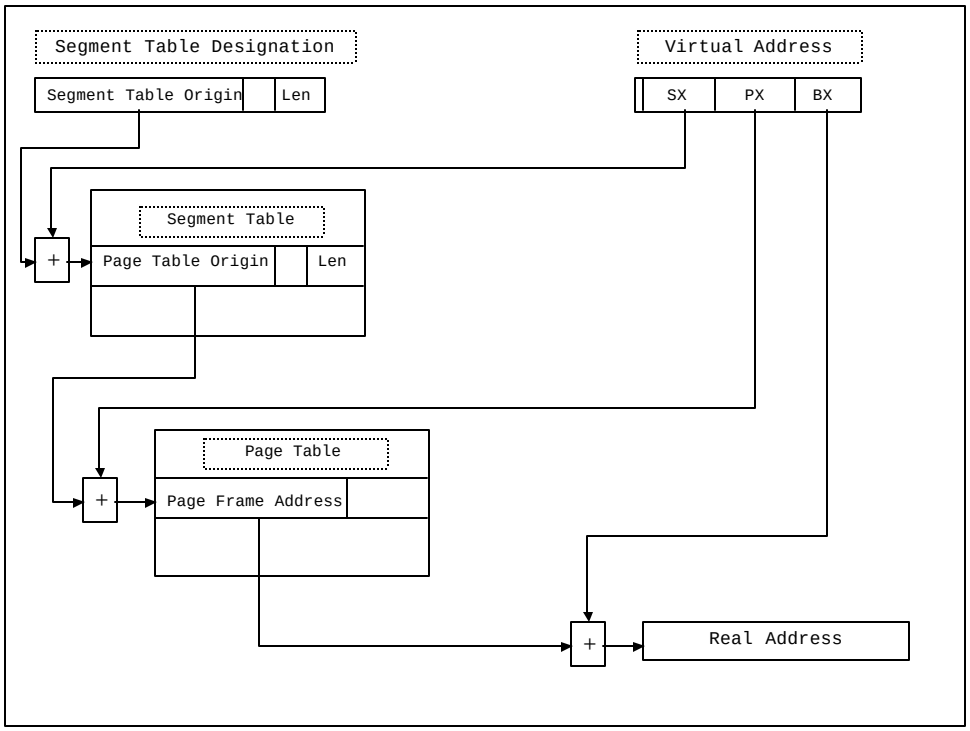

## Linux for S/390 & zSeries

- 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:

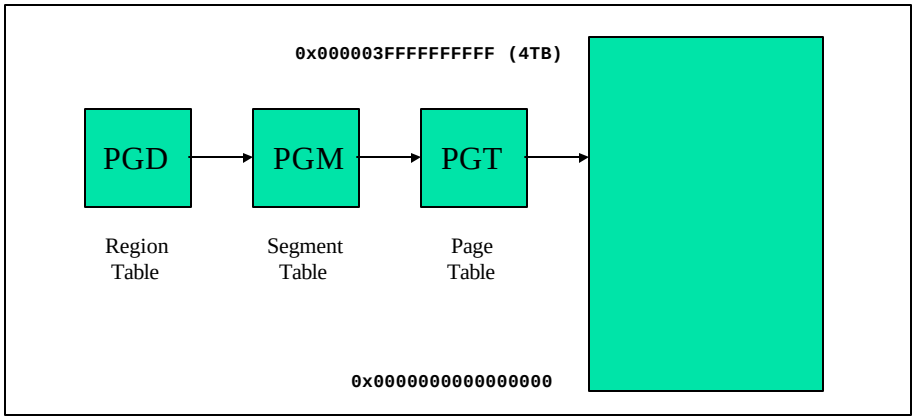





## Linux for zSeries

- 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!

## 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

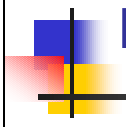
```
0000000080000000-0000000080008000 r-xp 0000000000000000 5e:01 207901 /bin/more
0000000080008000-0000000080009000 rw-p 0000000000007000 5e:01 207901 /bin/more
0000000080009000-000000008000d000 rwxp 0000000000000000 00:00 0
0000020000000000-000002000001b000 r-xp 0000000000000000 5e:01 223562 /lib/ld-2.2.2.so
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
000003fffffd000-0000040000000000 rwxp ffffffffffffe000 00:00 0
```

## New Device Drivers

- Tape
  - 3490
  - Character and block
- 3270
  - Console
  - Standard terminal
- Cisco Routers

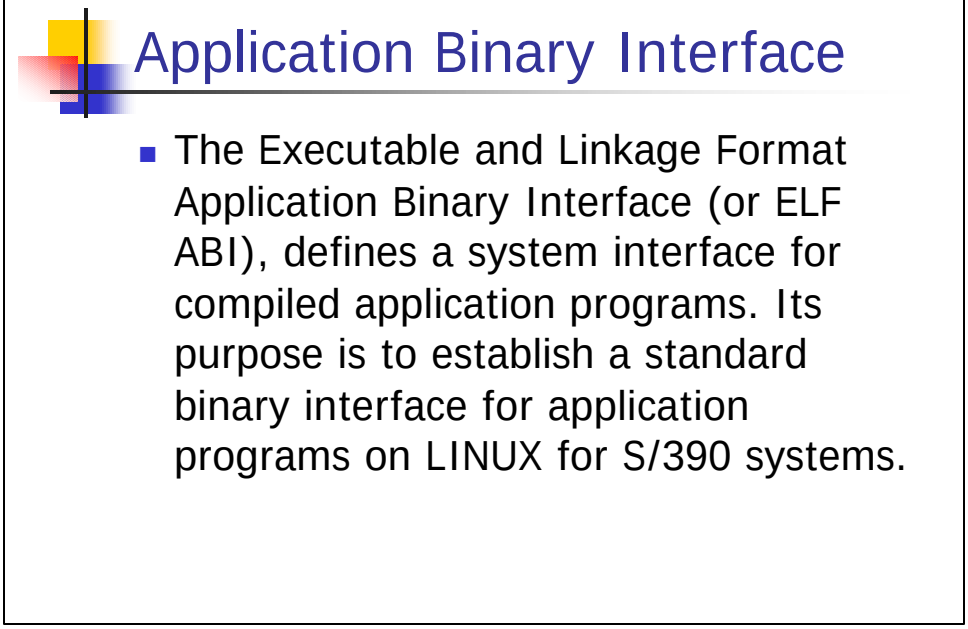
## Device Drivers

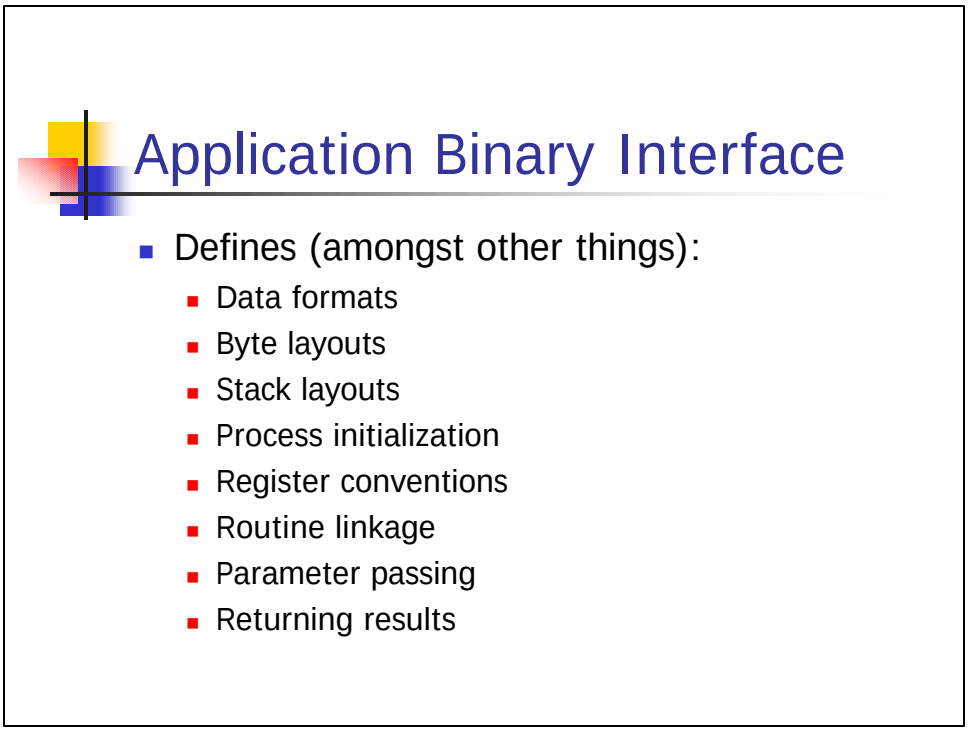
- CCWs must live “below-the-bar”
- Kernel supports memory requests for under the bar storage
- Device drivers build CCW programs in this storage
- IDALs used to address “above-the-bar” storage

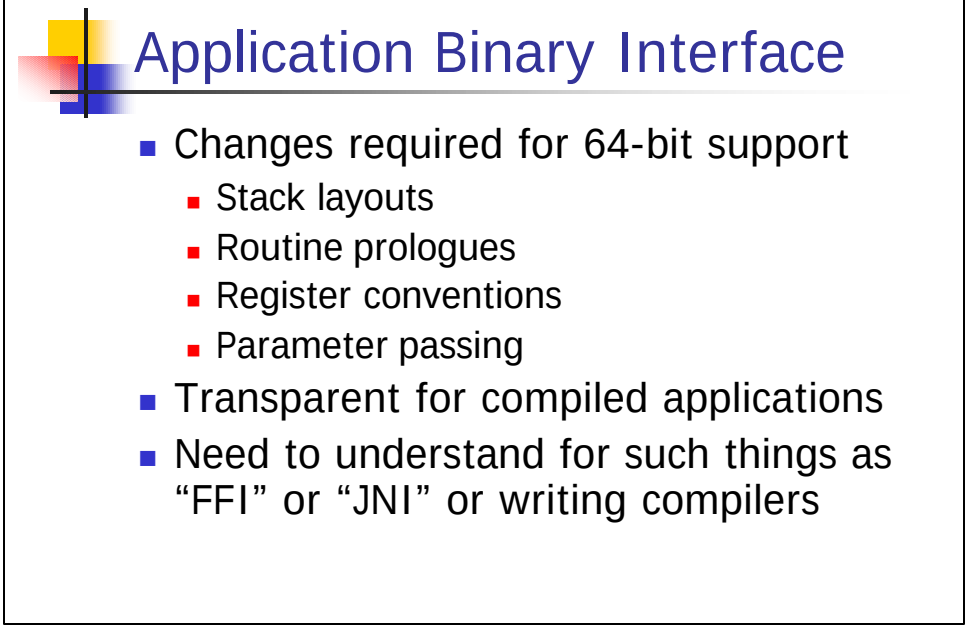


## Linux for zSeries

ABI Changes

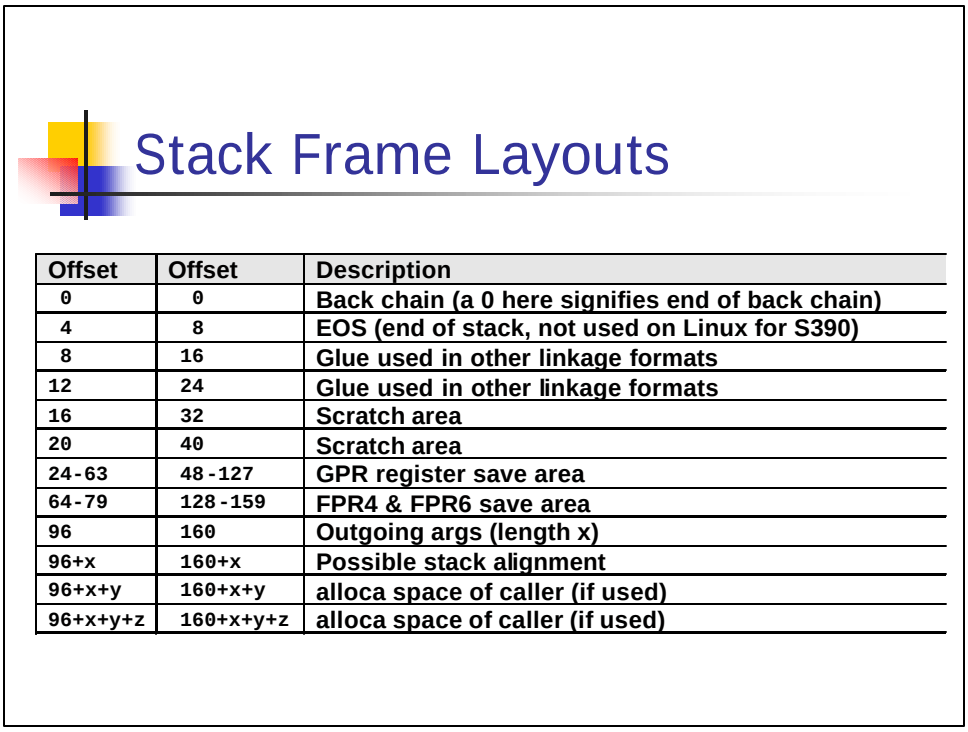




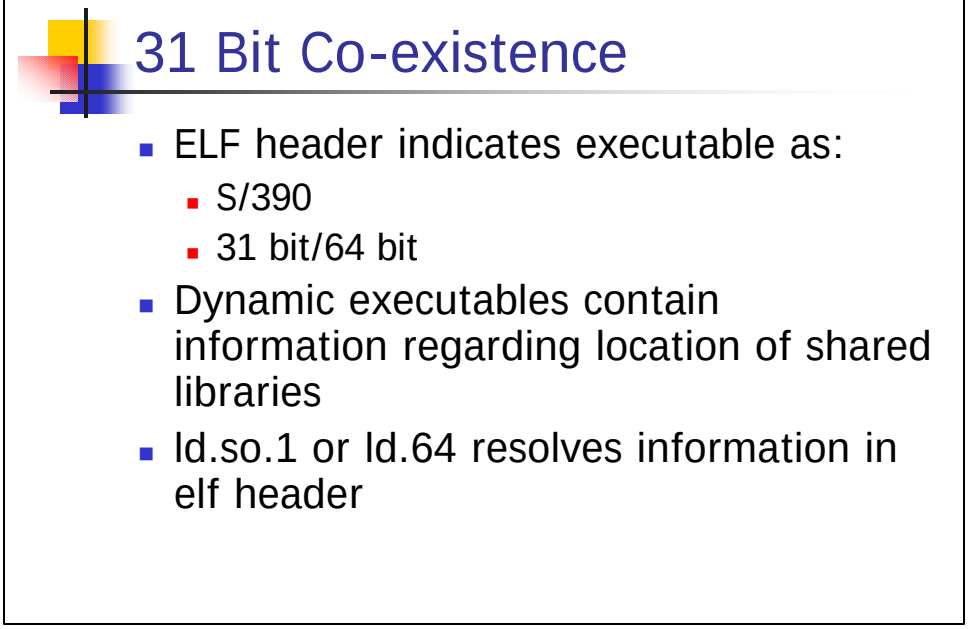
## Application Binary Interface

- 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



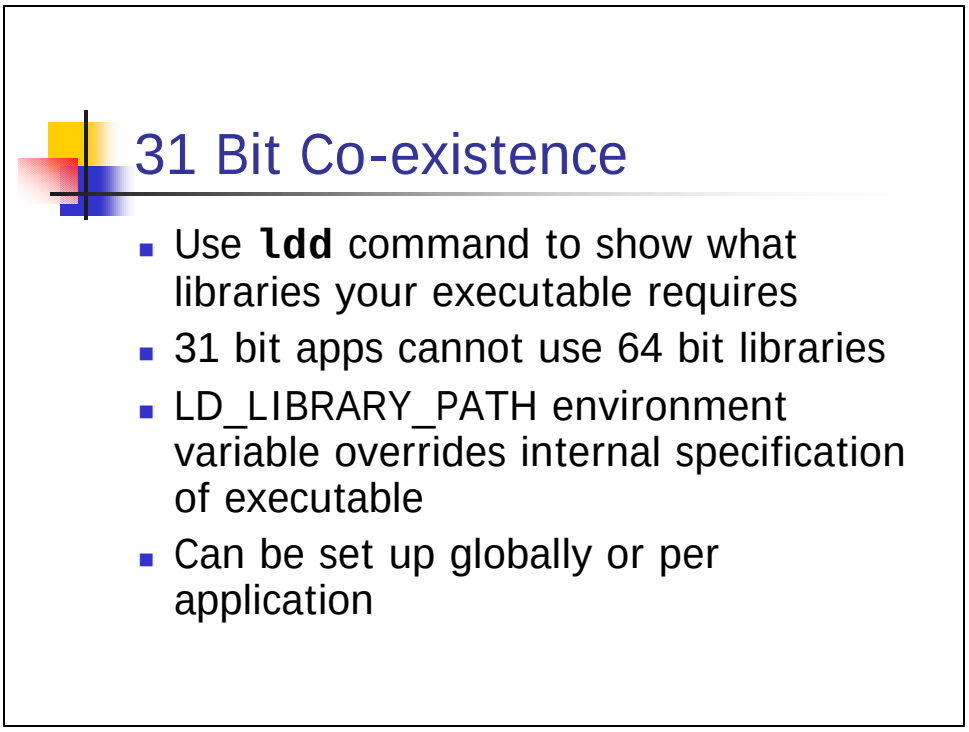
## Stack Frame Layouts

| 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 | alloca space of caller (if used) |



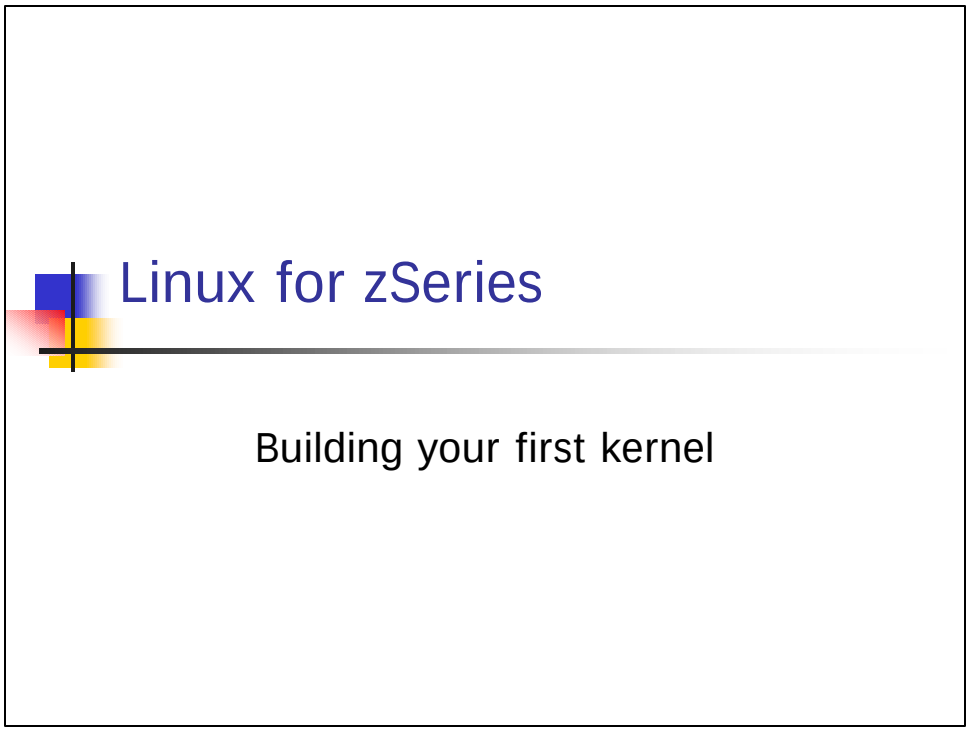
## 31 Bit Co-existence

- 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




## Building your first Kernel

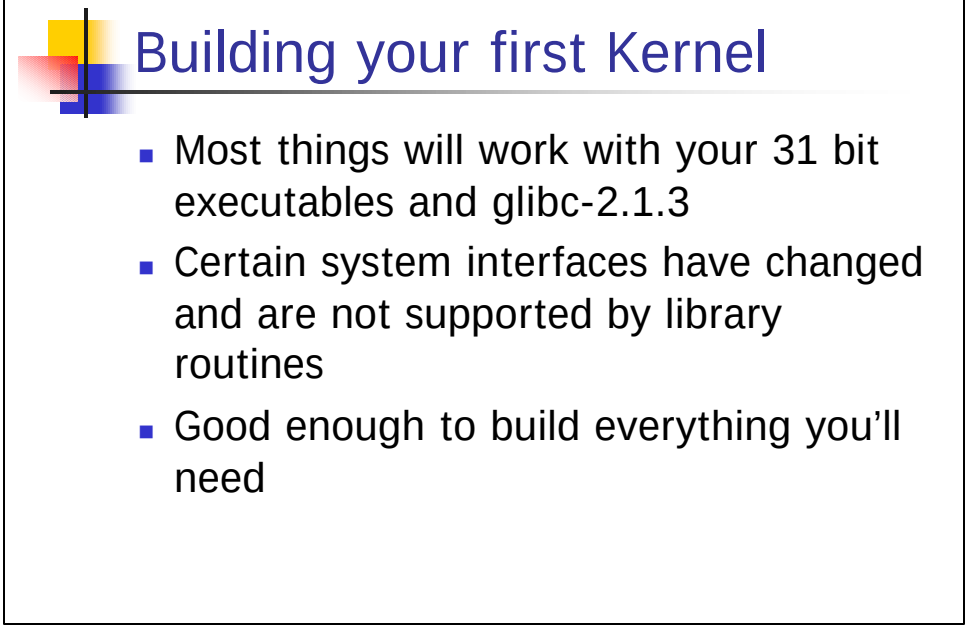
- Create a cross-compile environment
  - **`binutils-2.10.0.8`** + experimental patches
  - **`gcc-2.95.2`** + experimental patches
  - **`glibc-2.2.2`** + experimental patches
- Download kernel from ftp.kernel.org
- Apply patches

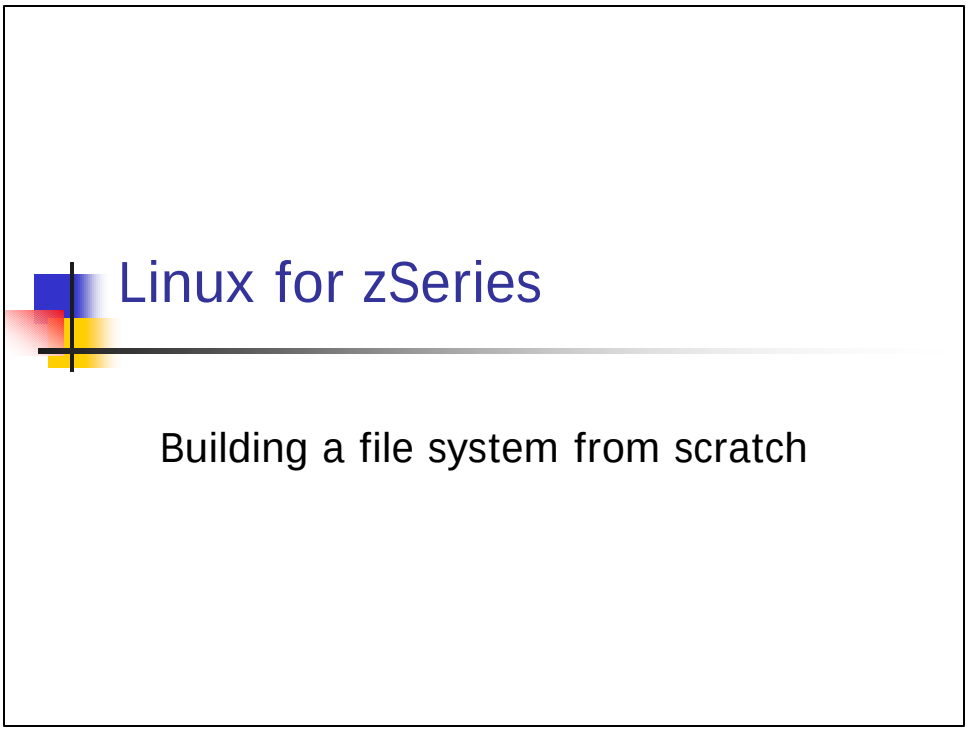
## Building your first Kernel

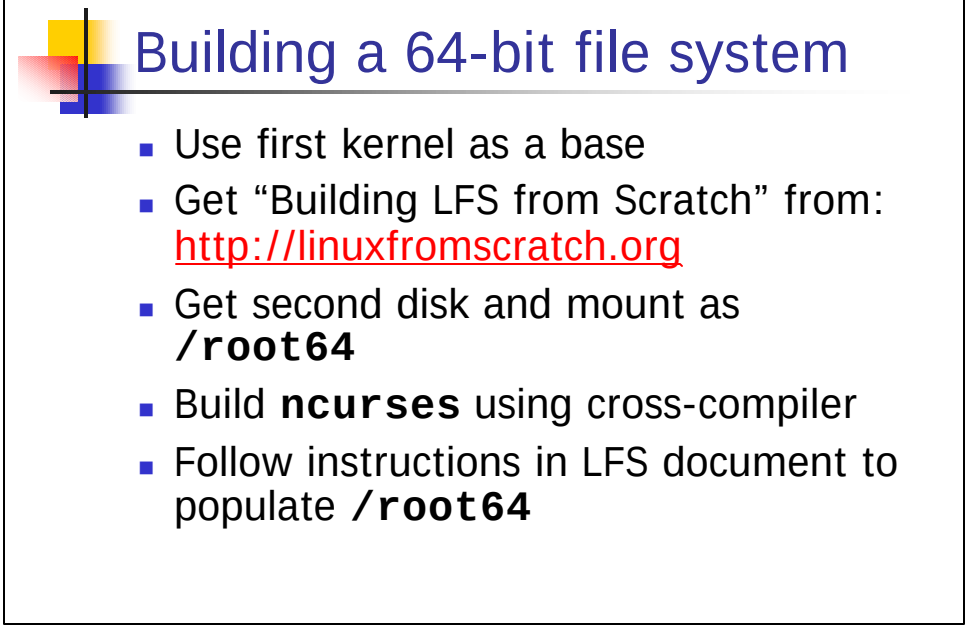
- Update Makefile:
  - **ARCH := s390x**
  - **CROSS_COMPILE=s390x-ibm-linux-**
- **make menuconfig**
- **make dep**
- **make**
- **make modules**
- **make modules_install**

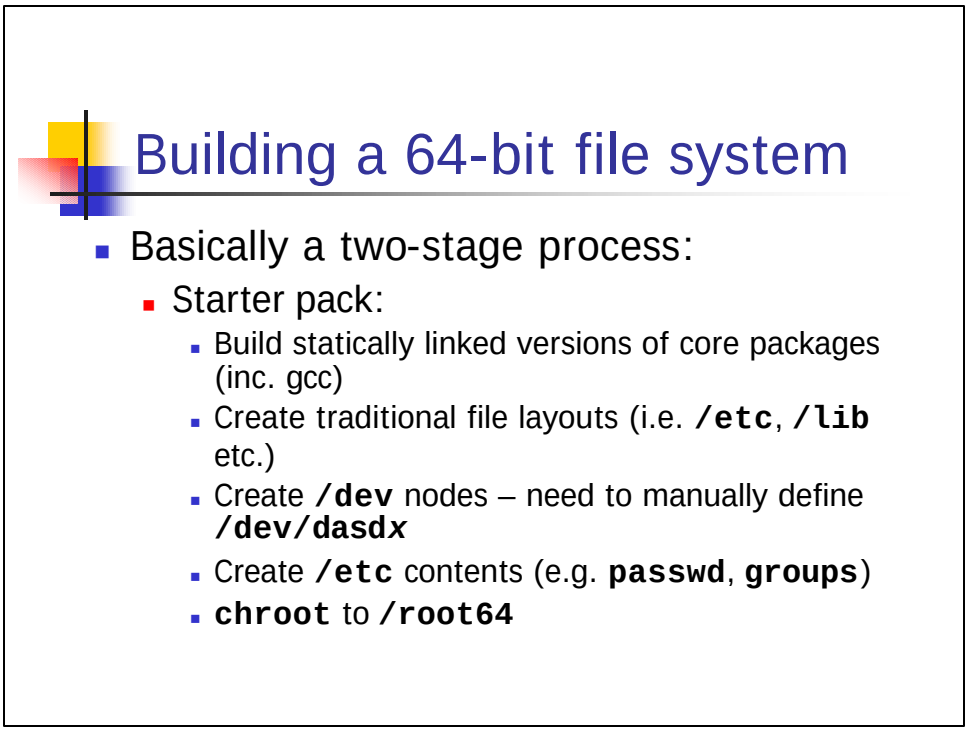
## Building your first Kernel

- Build silo:
  - **cd arch/s390x/tools/silo**
  - **make**
- Copy files to /boot:
  - **cp arch/s390x/boot/image /boot**
  - **cp arch/s390x/boot/*.boot /boot**
  - **cp System.map /boot**
- Run silo:
  - **cd /boot**
  - **<path-to-kernel-tools>/silo –f image –p parmfile –d /dev/dasdx**





## Building a 64-bit file system

- Production pack:
  - Build new glibc-2.2.2
  - Rebuild core packages - this time dynamically linked
  - Create and tailor startup scripts
  - Copy **`/boot`** contents & **`/lib/modules`**
  - Update parameter file and run **`silo`**
  - Run **`depmod`**
  - Reboot off the /root64 disk

## Linux for zSeries

ThinkBlue64 – ***Very*** Early Experiences

## ThinkBlue64

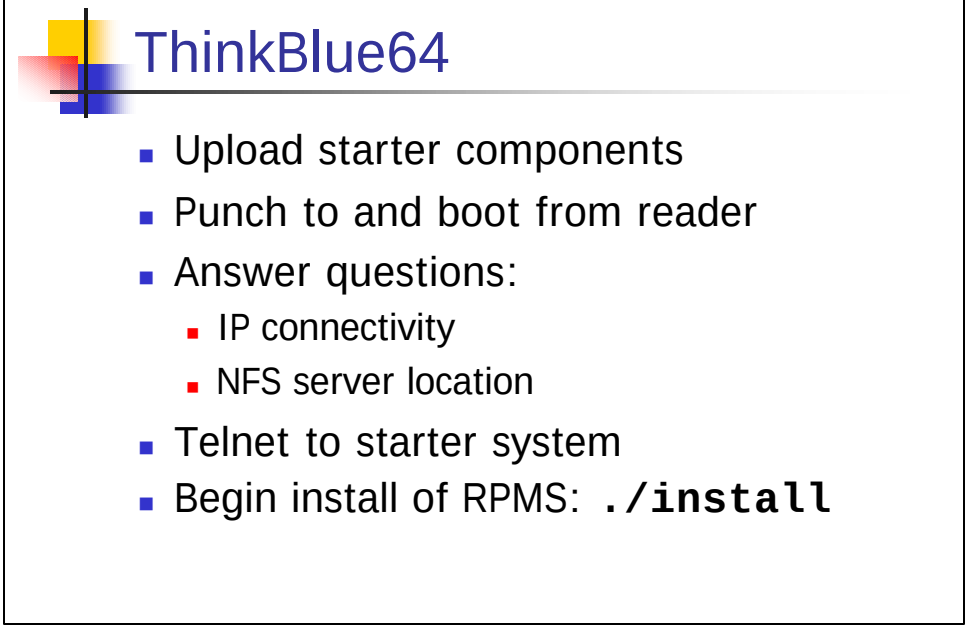
- Redhat-like distribution
- Download from http://linux.zseries.org
- CDROM ISO image available
- 749 RPMS
- Starter system:
  - Kernel (tape or VM reader)
  - Initial RAMDISK (tape or VM reader)
  - Parameter file

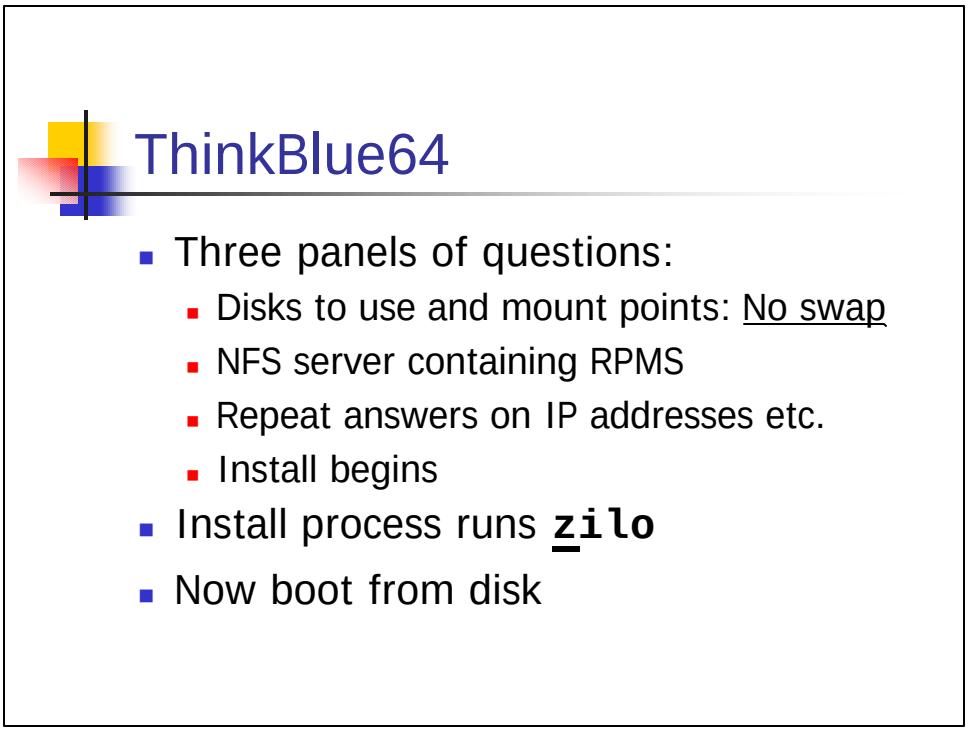
## ThinkBlue64

- Starting:
  - Mount CDROM on another Linux system:
    ```
    mount –o loop ThinkBlue64-disc1.iso /mnt/cdrom
    ```
  - Add **/mnt/cdrom** to **/etc/exports** and restart NFS server

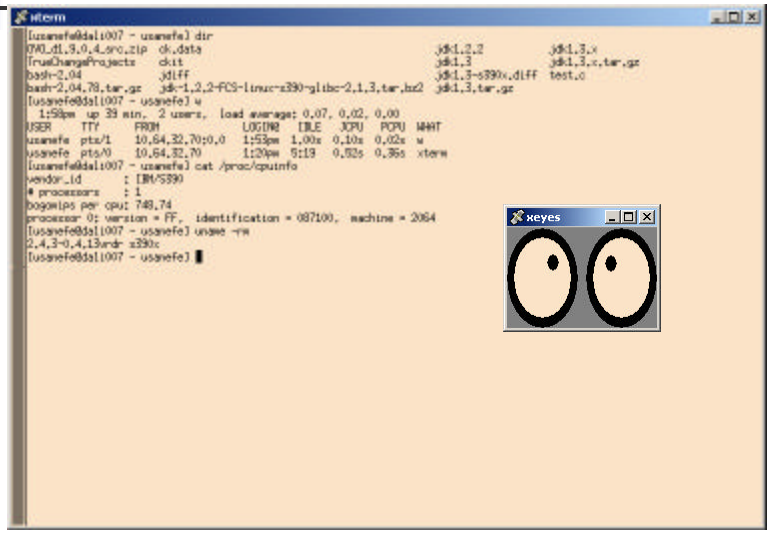
```
# See exports(5) for a description.
# This file contains a list of directories exported to other computers
# It is used by rpc.nfsd and rpc.mountd.
/mnt/cdrom      10.20.45.7(rw;no_root_squash)
```

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



## ThinkBlue64




## ThinkBlue64

- Current work:
  - Bash2
    - Problem with signal handling: Union of pointer and int
  - Regina ported!!!
  - JDK 1.3
    - Porting invokeNative_s390.S
    - Instructions: **`sllg r1,r1,2`** versus **`sll r1,2`**
  - Assessing requirements & efforts for SAG products
    - Tamino currently runs on Linux for S/390
  - Samba 2.2 has just gone GA on other platforms