News on the Linux kernel side:Important changes for zSeries

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Agenda

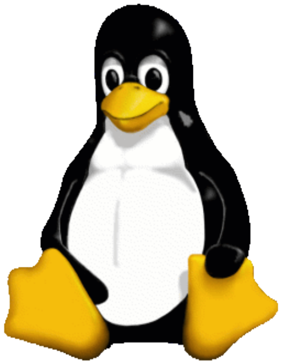
- **Development Process of Linux on zSeries**
- **Linux 2.6 overview**
- **Detailed look at zSeries**
- **Summary**
- **Discussion**

The Linux on zSeries Development Model

- **Kernel 2.4 model**
  - Code drop on developerWorks
  - Vanilla kernel (kernel.org) has been often not up-to-date
- **New model**
  - Code drop is still available and serviced
  - For production use, we suggest to use a distribution kernel
  - As of 2.5 kernels the vanilla kernel has been much more up-to-date and contains most of the changes from the latest code drop
  - It is possible to use the latest vanilla kernel for custom test kernels or as a base for distributions

What is new in Linux 2.6

- **There are lots of new features in 2.6....**
  - O(1) scheduler, kernel preemption
  - New device model / sysfs
  - Improved scalability / locking
  - More users, groups, PIDs
  - Networking: epoll, IPSEC
  - Threading: NPTL
  - More file systems, Access Control Lists
  - Asynchronous I/O
  - .....



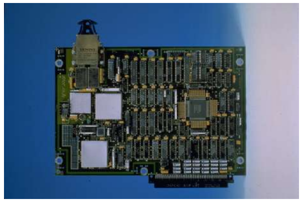
What is new after Linux 2.6.0?

- **...And several new items after 2.6....**
  - CPU hotplug
  - Block Device Layer
    - I/O barrier support
    - Scalability: per backing dev-unplugging
    - CFQ disk I/O scheduler
  - Snapshot, and mirroring in the device mapper
    - session about device mapper->check the updates
  - 4k kernel stacks
  - Object-based reverse mapping VM

Impact?

- **...So, what items are important for zSeries?**
  - Not all features affect zSeries
    - IDE layer update
    - Desktop interactivity work
  - Some changes help but are not that important
    - O(1) scheduler
    - Kernel preemption (deactivated on most distributions)
  - Other changes affect zSeries
    - Device model
    - Memory management
    - Block device layer
    - Code cleanups

Device Model



- **Device handling in Linux 2.4**
  - Linux 2.4 and earlier kernels have no deep knowledge about the hardware, the attached devices and their relationship
  - Device drivers and subsystems are responsible for handling systems
  - Issues with power management on x86 (suspend and resume) as well as hotplug

- **Introduction of a completely new device model**
  - Linux 2.6 has a hierarchical view about all devices
  - The kernel offers several views on the hardware

Sysfs

- **The internal representation is exported via sysfs**
- **Sysfs is a virtual file system, often mounted on /sys**
- **all attached devices are visible in sysfs**

```
/sys/
├── block
├── bus
├── class
├── devices
├── firmware
└── module
```

```
/sys/devices/
├── css0
├── platform
├── qeth
└── system
```

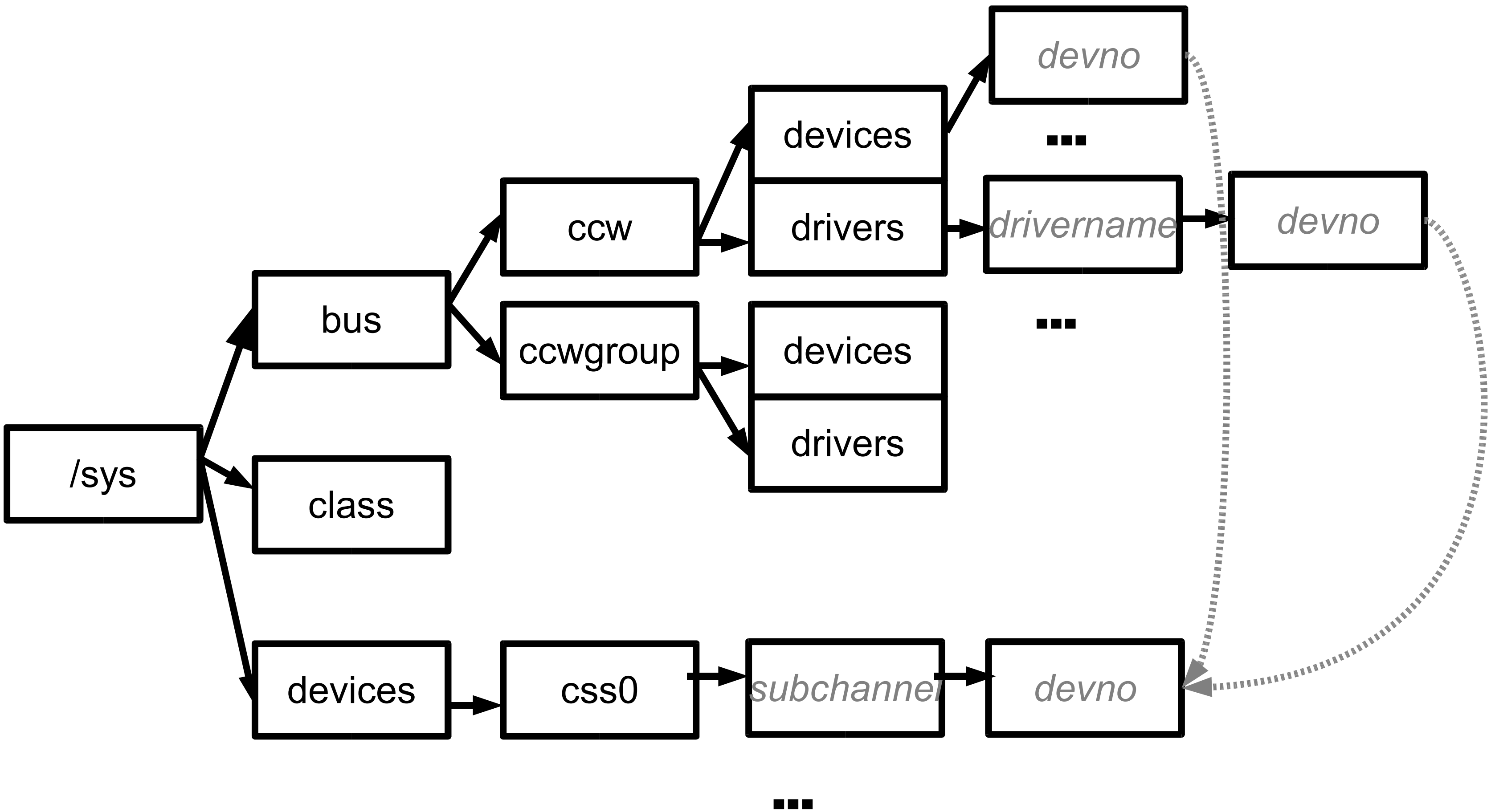
```
/sys/devices/css0
├── 0.0.0000
│   └── 0.0.5c18
├── 0.0.0001
│   └── 0.0.5c19
├── 0.0.0002
│   └── 0.0.f572
├── 0.0.0003
│   └── 0.0.f573
├── 0.0.0004
│   └── 0.0.f574
.....
├── 0.0.001c
│   └── 0.0.5468
├── chp0.40
....
├── chp0.fc
└── chp0.fd
```

```
/sys/devices/css0/0.0.0000/0.0.5c18/
├── availability
├── block -> ../../../../block/dasda
├── cmb_enable
├── cutype
├── detach_state
├── devtype
├── discipline
├── online
├── readonly
└── use_diag
```

Linux Common I/O Layer

- **All channel devices are driven by channel programs consisting of channel command words**
- **These devices are called ccw devices in Linux**
  - DASD, OSA devices, zFCP devices...: `/sys/bus/ccw/`
- **Some devices have more than one device number: grouped ccw devices (ccwgroup)**
  - OSA network adapter.... `/sys/bus/ccwgroup/`
- **Every Device is part of the hierarchy**
- **Device model offers different views**
- **Concept of devices, busses and classes**

Sysfs


devno
devices
...
ccw
drivers
drivername
devno
bus
ccwgroup
devices
...
/sys
drivers
class
devices
css0
subchannel
devno
...

Sysfs

- **Use sysfs to configure almost every device**
- **Use the online attribute to enable/disable a device**
  - `echo 1 > /sys/bus/ccw/devices/0.0.0190/online`
  - `echo 0 > /sys/bus/ccw/devices/0.0.0190/online`
- **chandev.conf is not supported (and not necessary)**
  - There is a conversion tool for SLES9 configuration files
    - /etc/sysconfig/hardware/scripts/chandev-to-hwcfg.sh
  - sysfs provides all means to configure devices

```
# echo 0.0.0100,0.0.0101,0.0.0102 > /sys/bus/ccwgroup/drivers/qeth/group
# echo hw_checksumming > /sys/bus/ccwgroup/devices/0.0.0100/checksumming
# echo 1 > /sys/bus/ccwgroup/devices/0.0.0100/online
```


Sysfs

- **To ease the use, IBM provides helper scripts**
- **lsdasd**
  – Similar to “cat /proc/dasd/devices”
- **lscss**
  – Similar to “cat /proc/subchannels”
- **lstape**
  – To show tape devices
- **chccwdev**
  – For enabling (-e) and disabling devices (-d)

Sysfs - distributions

- **configuration via sysfs is usually made by your distribution**
- **SUSE SLES9**
  - hwup and hwdown using the config files in `"/etc/sysconfig/hardware"`
  - ifup and ifdown using the config files in `"/etc/sysconfig/network"`

Hotplug

- **Automation the reaction on hardware changes**
  - In case of hardware events, the kernel calls a program or script "`/sbin/hotplug`" with several parameters
  - Events are for example device add and removal
  - `/sbin/hotplug` is a multiplexer, which calls several agents
  - The administrator can configure hotplug to automize Linux
- **Hotplug is integral part of the kernel**
  - In Linux 2.4, every device driver has been responsible for the creation of hotplug events: lots of duplicated code
  - In Linux 2.6, every device drivers which uses the device model gets hotplug for free

udev

- **User can access devices via device nodes**
  - To read the first DASD partition you can read `/dev/dasda1`
  - Device nodes are normal files, which need to be created
    - Static device nodes
      - Created by the administrator
    - Devfs (deprecated)
      - Kernel file system
      - Device nodes are created by the kernel
      - How to define the policy?
    - Udev:
      - Application, that creates device nodes using hotplug and sysfs
      - Udev is the proposed way to handle device nodes
      - Possible using the device model

udev – how it works

- **The kernel calls /sbin/hotplug with parameters**
- **/sbin/hotplug multiplexes events and calls udev**
- **Environment variables (examples)**

DEVPATH=/class/net/eth1
PATH=/sbin:/bin:/usr/sbin:/usr/bin
ACTION=add
PWD=/
SHLVL=1
HOME=/
INTERFACE=eth1
SEQNUM=196

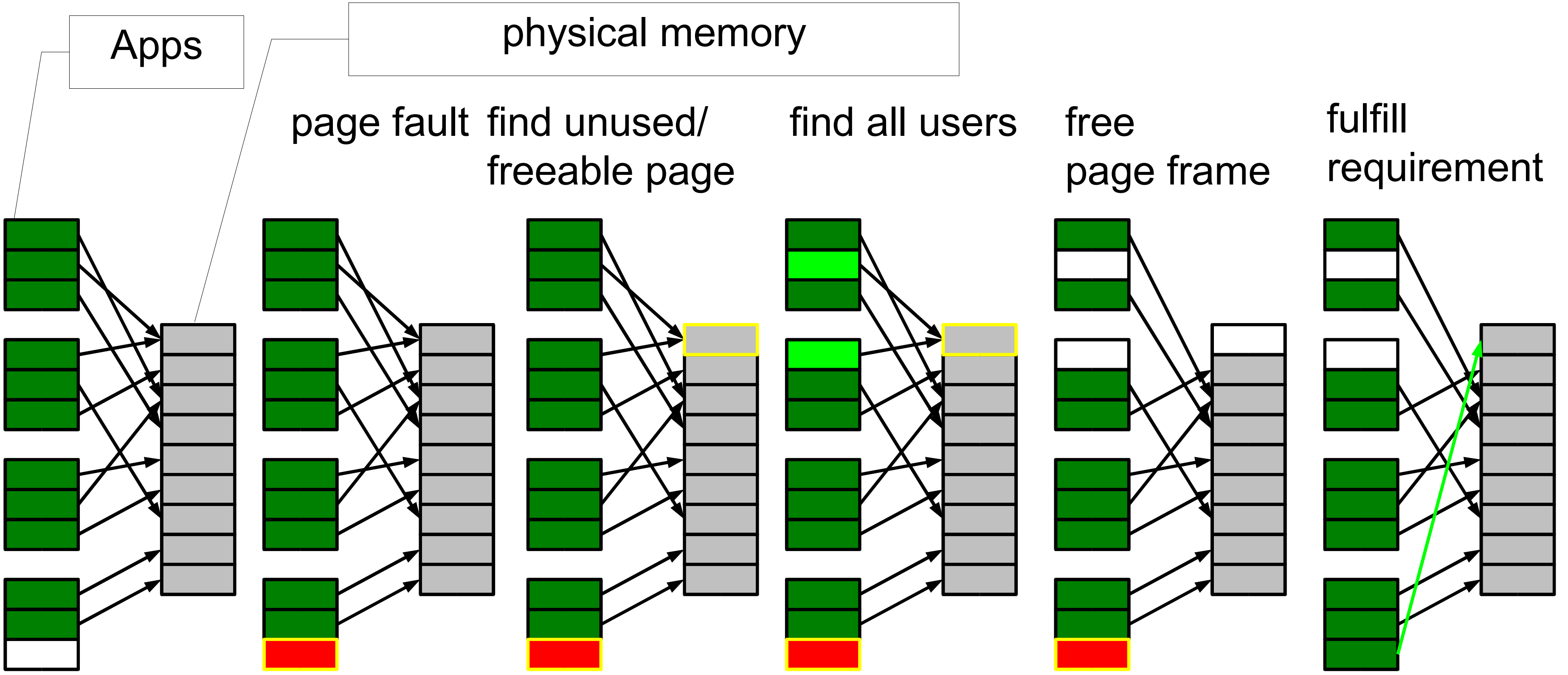
DEVPATH=**/block/dasdb**
PATH=/sbin:/bin:/usr/sbin:/usr/bin
ACTION=add
PWD=/
SHLVL=1
HOME=/
SEQNUM=201

See my session on Tuesday

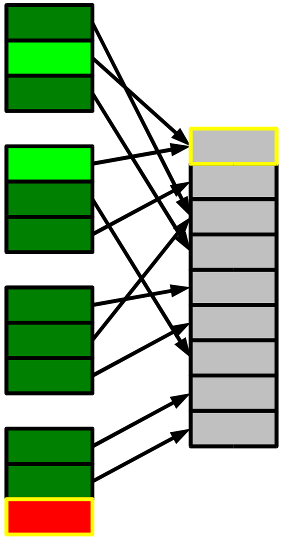
- `/sys/block/dasdb/dev` **contains major and minor number**
- `/etc/udev/udev.rules` **and** `/etc/udev/udev.permissions` **define udevs policy which creates a device node using the major number, the minor number**

Memory Management

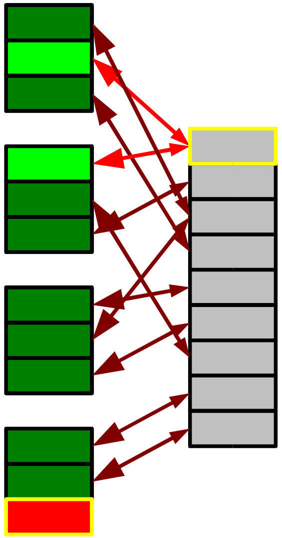
- **How does Linux handle a memory request if memory is exhausted?**



Memory Management



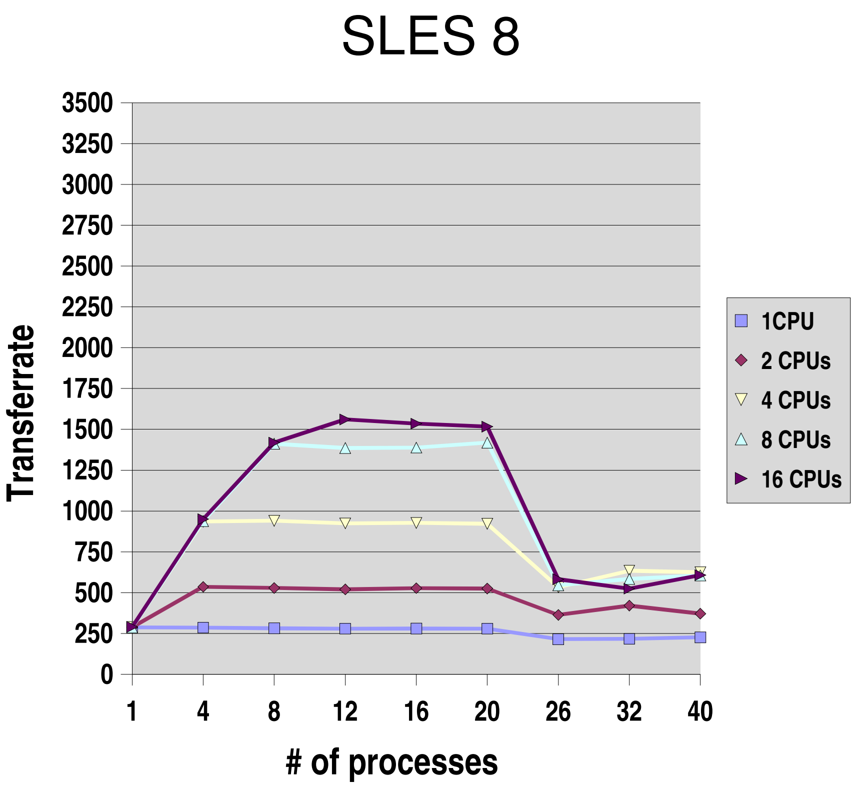
- **ISSUE:**
  - Finding all users is expensive
  - Kernel has to lookup every process
- **SOLUTION:**
  - Add additional information about every physical page. Feature is called reverse mapping and is available for all platforms
  - There has been a small overhead, which was addressed using objective rmap

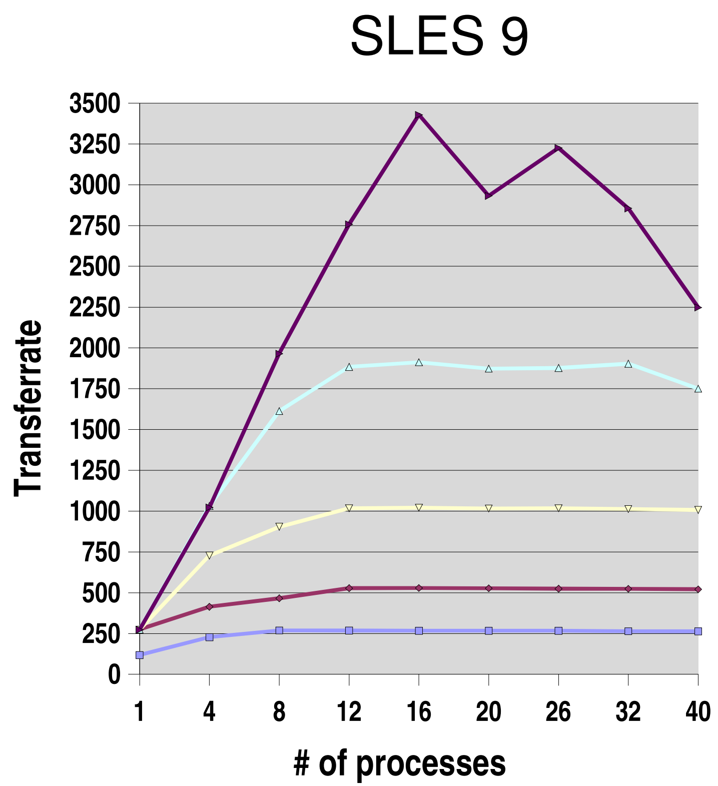


Memory Management

- **virtual memory**
  - More optimizations based on rmap
  - Every operating system that provides virtual memory needs to keep track whether memory pages are used to read or write
  - Pages which are written to are called “dirty”
  - The dirty information is usually stored in a bit
    - Per virtual page on x86
    - Per hardware page on zSeries
  - zSeries difference allows optimizations
  - Kernel 2.6 offers the infrastructure to exploit the hardware feature

dbench scalability



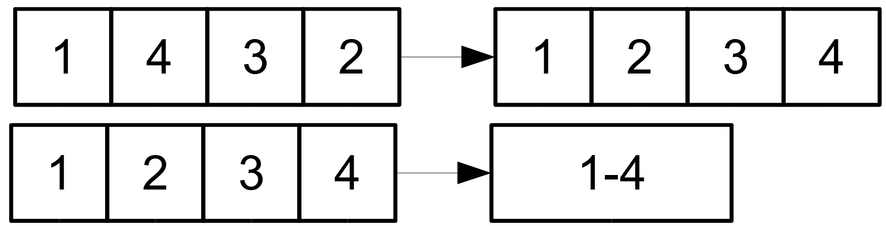


Block Device Layer

- **Responsible for block devices**
  - Random access devices
  - Addressable in blocks
  - e.g. DASD, floppy disks, xpram, ...
  - Responsible for optimizing the access to block devices
    - Maximize throughput
    - Minimize latency
    - Fairness
    - There is no optimal algorithm

Block Device Layer - I/O scheduler

- **I/O schedulers can improve the performance**
  - Reorder requests
  - Merge requests



- **It is not that easy...**
  - Competing processes
  - Mixed write and read requests
  - Heuristics are used

Block Device Layer - internals

- **Data transfer is organized in request queues**
  - Input and output goes through request queues
  - Request queues can be plugged(stopped) and unplugged (running)
- **Why plugging?**
  - Only stopped request queues can be optimized
  - I/O scheduler optimizes plugged(stopped) queues
  - Afterwards the queues are unplugged to start the optimized I/O operations

Block Device Layer - news

- **The block device layer has been completely rewritten during the 2.5 phase**
  - Improved internal data structures
    - Higher flexibility and scalability
  - Unplugging per device instead of global unplugging
  - Larger block devices up to 16TB/8EB (32/64bit)
  - Modular I/O schedulers
    - You can choose the optimization strategy
    - Better performance than 2.4
    - You can choose the I/O scheduler using the elevator kernel parameter `(elevator=as,deadline,noop,cfq)`

Threading

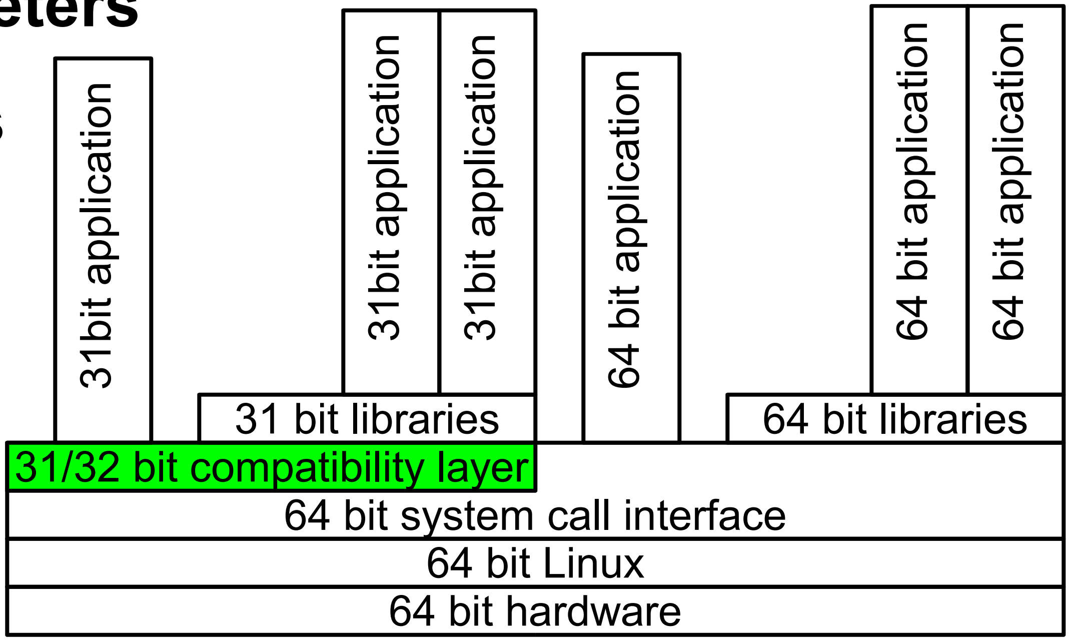
- **NPTL (Native POSIX Thread Library)**
  - A new user space library boosts performance of multithreaded applications. Several kernel features are used:
    - Thread Local Storage (TLS)
    - Futex ('Fast Userspace muTexes')
  - Transparent for the application (binary compatible)
    - Most applications will run with the new library
    - Nevertheless, there is a change in behavior, to comply with POSIX standard
    - In case of trouble with old applications, try to run with
      - `LD_ASSUME_KERNEL=2.4.18 <command>`

CPU hotplug

- **It is now possible to set CPUs online / offline**
- **Access via /sys/devices/system/cpu/cpu<num>**
- **Activate CPUs on the fly**
  - `#CP DEFINE CPU 1`
  - `echo 1 > /sys/devices/system/cpu/cpu1/online`
- **Deactivate CPUs**
  - `echo 0 > /sys/devices/system/cpu/cpu3/online`
  - sends a SIGP STOP to the CPU
- available on SLES9 SP1

System Call Emulation

- **It is possible to run 31bit applications on a 64bit system mixed with 64bit applications**
- **Same functionality for sparc, ppc, x86-64, mips**
- **Translation of parameters**
- **Translation of results**
- **Transparent**



System Call Emulation

- **What has been wrong with 2.4?**
  - In Linux 2.4 every architecture has provided its own layer
  - All implementations are inspired by sparc64 code
  - Lots of code duplicates (including errors)
  - Bug fixes have been often applied to one architecture only
- **Whats new in 2.6?**
  - Common code for all architectures has been created
  - Ongoing process of moving the feature into common code
  - Several errors fixed during the consolidation:higher quality
  - Aim: emulated 31 bit exactly as good as native 31 bit

System Call Emulation

- **What do I need to run a 31 bit application on 64bit?**
  - All necessary libraries must be available in 31 bit as well
  - Some mixed JAVA/native code applications need 31 bit JAVA libraries as well
  - Usually 64 bit libraries are `/lib64/`, `/usr/lib64/` ...
  - 31 bit libraries are `/lib/` , `/usr/lib/`...
  - Use ldd to see the dependencies

```
# ldd /bin/bash
                libreadline.so.4 => /lib64/libreadline.so.4 (0x0000010000021000)
                libhistory.so.4 => /lib64/libhistory.so.4 (0x0000010000063000)
                libncurses.so.5 => /lib64/libncurses.so.5 (0x000001000006c000)
                libdl.so.2 => /lib64/libdl.so.2 (0x00000100000d4000)
                libc.so.6 => /lib64/libc.so.6 (0x00000100000d8000)
                /lib/ld64.so.1 => /lib/ld64.so.1 (0x0000010000000000)
```

On Demand Timer Patch

- **Linux uses a regular timer for internal work**
  - 100 or 1000 ticks per second
  - Timer tick has a relevant overhead having many guests
- **IBM provided a patch to deactivate the timer on idle systems**
  - Integrated into SLES8 and SLES9
  - Since 2.6.6 part of the standard Linux kernel
  - /proc/sys/kernel/hz_timer
    - Set to 0 to deactivate the regular tick (patch enabled)
    - Set to 1 to activate the regular tick (default, patch disabled !)

zipl – some news besides the kernel

- **Zipl allows to define a boot menu**
  - You can define several configurations containing of all possible options
    - Kernel
    - Initrd
    - Parameters
  - Configuration

```
[defaultboot]
        defaultmenu = menu
[ipl]
                target = /boot/zipl
                image = /boot/image
                ramdisk = /boot/initrd
                parameters = "root=/dev/dasda1 selinux=0 TERM=dumb elevator=cfq"
[test]
                target = /boot/zipl
                image = /boot/image-test
                ramdisk = /boot/initrd-test
                parameters = "root=/dev/dasda1 dasd=1234 selinux=0 TERM=dumb"

:menu
1=ipl
2=test
target=/boot/zipl
default=1
timeout=10
prompt=1
```


zipl

- **You can choose the configuration at boot**

```
00: zIPL v1.3.1 interactive boot menu
00:
00:  0. default (ipl)
00:
00:  1. ipl
00:  2. test
00:
00: Note: VM users please use '#cp vi vmsg <input>'
00:
00: Please choose (default will boot in 10 seconds):
```

- **You can also pass kernel parameters**
  - **e.g.:** `#cp vi vmsg 1 dasd=1000-1fff`
- **Ideal for recovery and testing**

Distributions

- **Which distributions offer Kernel 2.6 support?**
  - SUSE SLES9 : GA August 2004
  - Red Hat RHEL4: GA 2005
  - Debian unstable
- **Other distributions will follow**
- **SUSE Linux supports upgrade SLES8 to SLES9**

Outlook

- **Linux 2.6 will see lots of improvements without any Linux 2.7**
  - Currently 10 MB/month of patches
- **Open source, IBM and other companies are developing more enterprise features**
  - CKRM: class based resource manager, something like z/OS WLM
- **Better integration with z/VM**
- **This presentation will probably look quite different in a year**

Developerworks

- **There are lots of features and changes**
- **This presentation give some details on some aspects**
- **Please ask me if:**
  - you want to know more about a specific feature
  - you miss some feature
  - you think we do something completely wrong

Summary

- Cleanups
- Rewrites
- Limits have been lifted
- Scalability was increased
- New device model
- New features

Question & Discussion

- **Now**
- **I am available afterwards**
  - After this session
  - Any time during WAVV
  - Email: cborntra@de.ibm.com
- **Thank you for your attention**

http://www.research.ibm.com/journal/sj/442/borntraeger.pdf

Backup Slides

Virtual Memory

- **Dirty bit handling**
  - Pages can be dirty or clean
  - If you remove a dirty page, you have to write the page back
  - The dirty/clean bit is usually stored in page table entries (per address space). To get the dirty information for a physical page, Linux used to query all processes
  - S/390 zSeries stores the dirty information in storage keys
  - Storage keys are already per physical page!
  - Optimization which led to drastic reduction in SSKE use

Kernel Build

- **For production use, distribution kernels suggested**
  - Support is available
  - 3590 OCOs are available
  - Well tested and serviced
- **For testing new features a kernel.org kernel will probably work fine**
  - No support
  - No 3590 OCOs

Architecture merge s390/s390x

- **Linux has 2 possible modes:**
  - 31bit, called s390 and 64bit, called s390x
- **Both modes were implemented by different Linux architecture code**
  - Lots of duplicated code
  - Possible inconsistencies
- **To improve stability both modes were collapsed into the same C-code**
  - Highly reduced code size!

The Linux Development Model

- **Previous model**
  - Even minor numbers (2.0, 2.2,2.4..) indicate a stable kernel
  - Odd minor numbers (2.1, 2.3...) indicate an unstable kernel
  - Major developments only in unstable kernels
- **New model**
  - There is a test environment called -mm kernels
  - mm kernel follows the vanilla kernel
  - Proved changes will be merged into the vanilla 2.6 kernel
  - No need for a kernel 2.7 at the moment