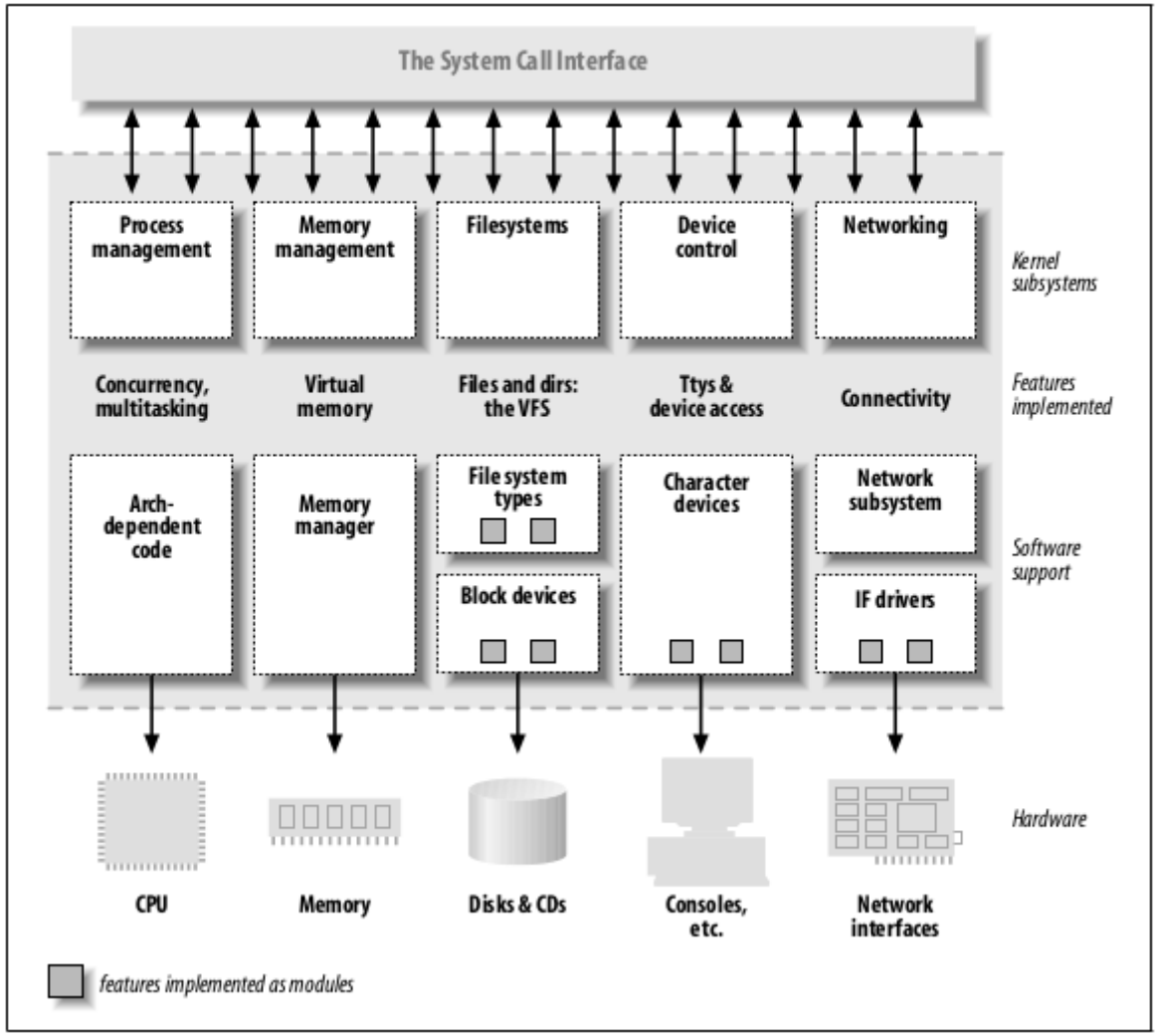
CH9 Linux Device Driver Module



Example

- **make**
- #sudo **insmod** simple.ko
- #dmesg | tail
- **#lsmod** | grep simple
- #sudo **rmmod** simple

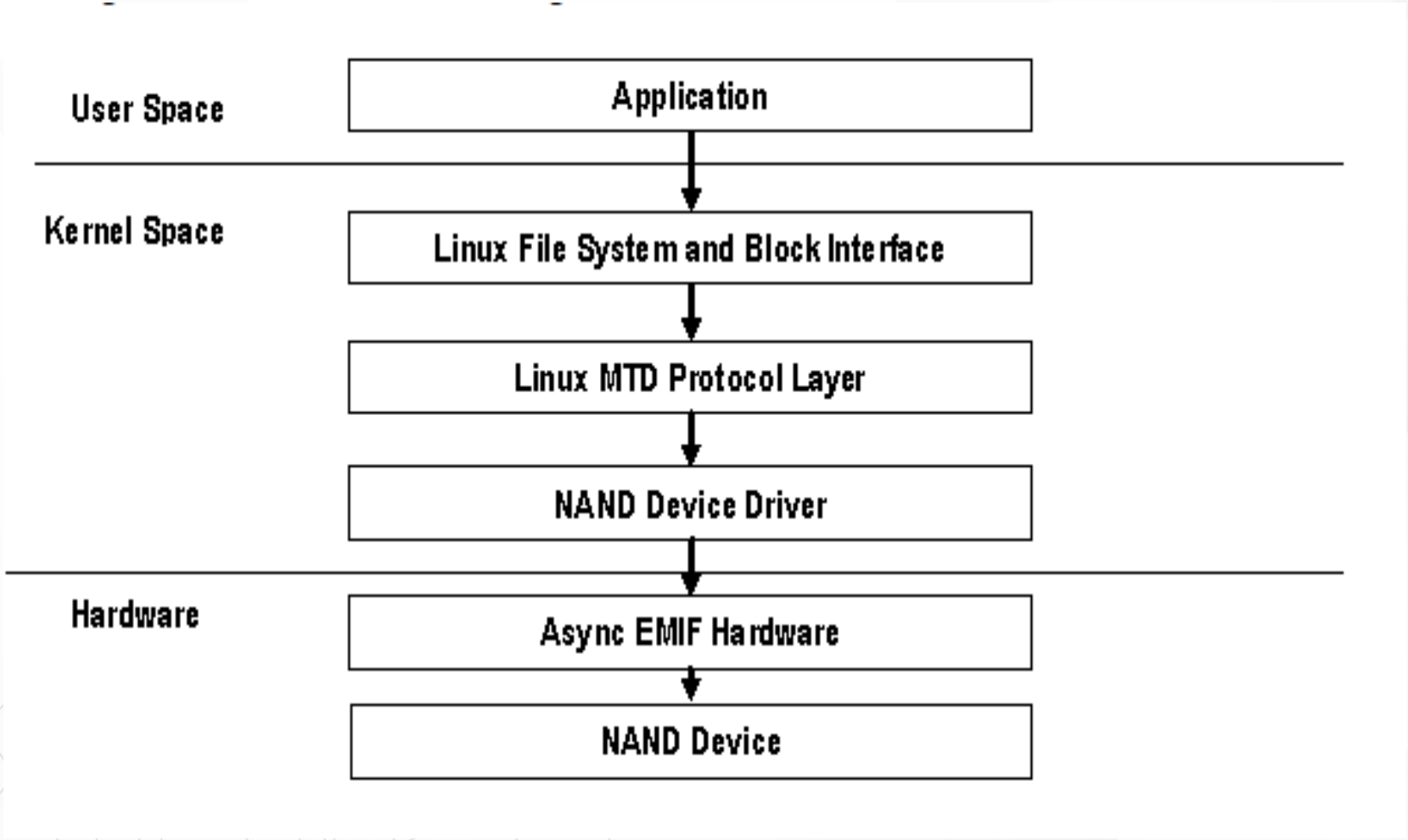
Classes of Devices Driver

- Char module
  - simple
  - access stream of bytes
- Block module
  - block and char devices differ only in the way data is managed internally by the kernel
- Network module
  - Manage network data packets

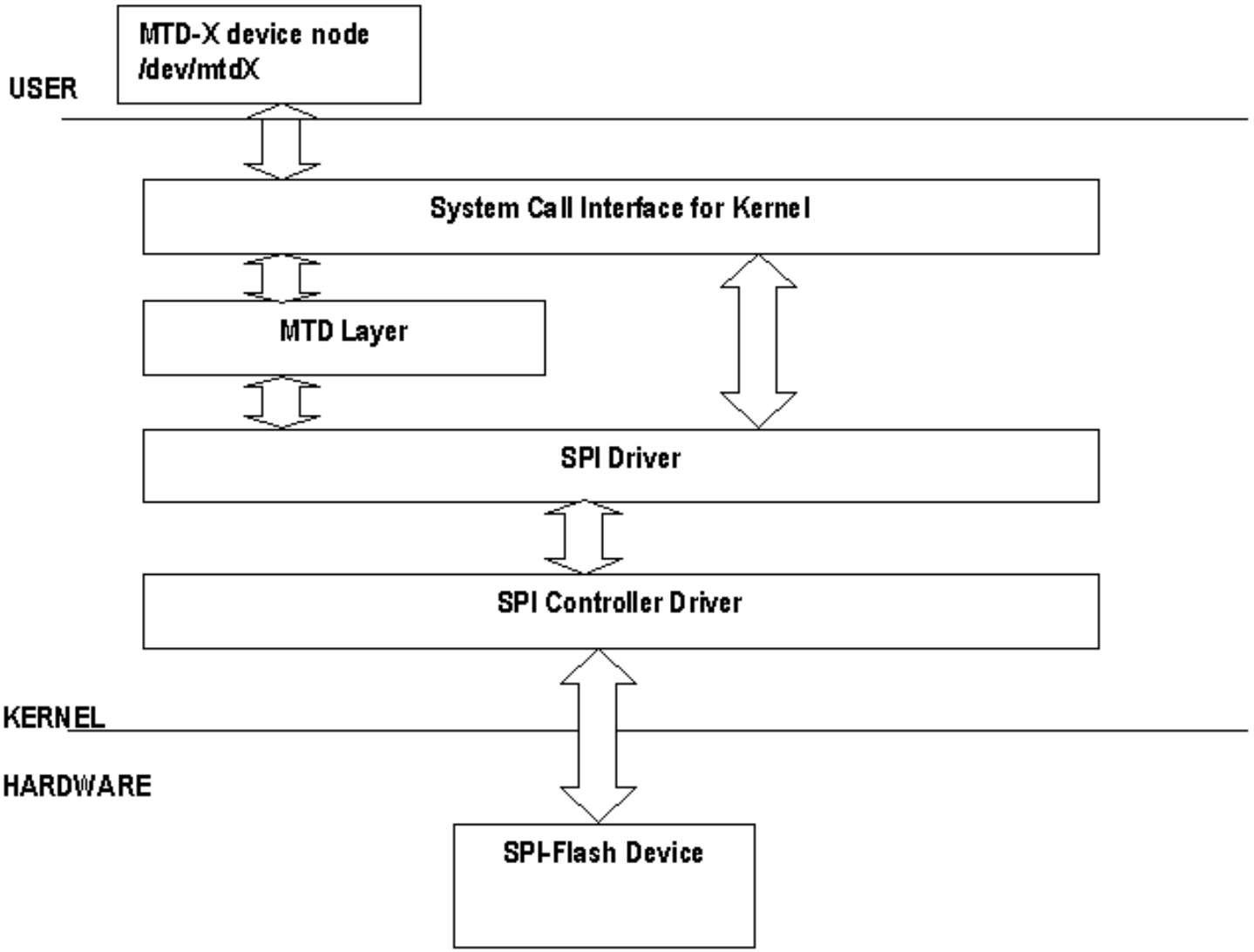
Sub-system

- Sub-system
- Module
- Driver

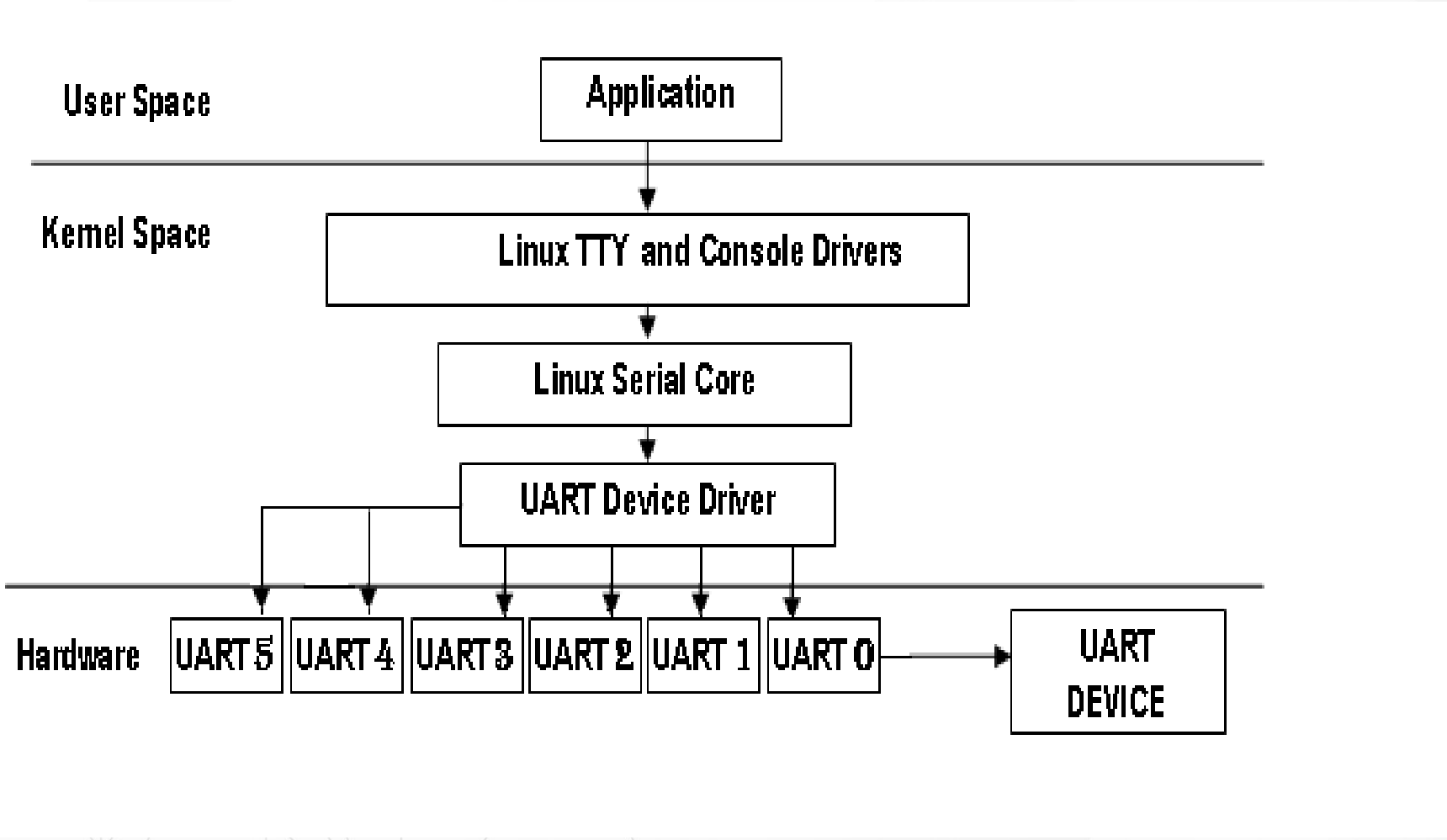
Sub-system



Sub-system



Sub-system



Character Driver

Character Driver

- Device file
- /dev
- #ls /dev -l

```
lrwxrwxrwx  1 root root           8 Jul 26 09:53 shm -> /run/shm
crw-------  1 root root      10, 231 Jul 26 09:53 snapshot
drwxr-xr-x  3 root root         360 Jul 26 09:53 snd
brw-rw----+ 1 root cdrom     11,   0 Jul 26 09:53 sr0
lrwxrwxrwx  1 root root          15 Jul 26 09:53 stderr -> /proc/self/fd/2
lrwxrwxrwx  1 root root          15 Jul 26 09:53 stdin -> /proc/self/fd/0
lrwxrwxrwx  1 root root          15 Jul 26 09:53 stdout -> /proc/self/fd/1
crw-rw-rw-  1 root tty        5,   0 Jul 26 11:13 tty
crw--w----  1 root tty        4,   0 Jul 26 09:53 tty0
crw-rw----  1 root tty        4,   1 Jul 26 09:53 tty1
crw--w----  1 root tty        4,  10 Jul 26 09:53 tty10
crw--w----  1 root tty        4,  11 Jul 26 09:53 tty11
crw--w----  1 root tty        4,  12 Jul 26 09:53 tty12
crw--w----  1 root tty        4,  13 Jul 26 09:53 tty13
crw--w----  1 root tty        4,  14 Jul 26 09:53 tty14
crw--w----  1 root tty        4,  15 Jul 26 09:53 tty15
crw--w----  1 root tty        4,  16 Jul 26 09:53 tty16
```

Major and Minor Numbers

- Major number
  - Classify drivers
- Minor number
  - Device number in same major number

```
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crw--w----  1 root tty           4,  13 Jul 26 09:53 tty13
crw--w----  1 root tty           4,  14 Jul 26 09:53 tty14
crw--w----  1 root tty           4,  15 Jul 26 09:53 tty15
crw--w----  1 root tty           4,  16 Jul 26 09:53 tty16
```
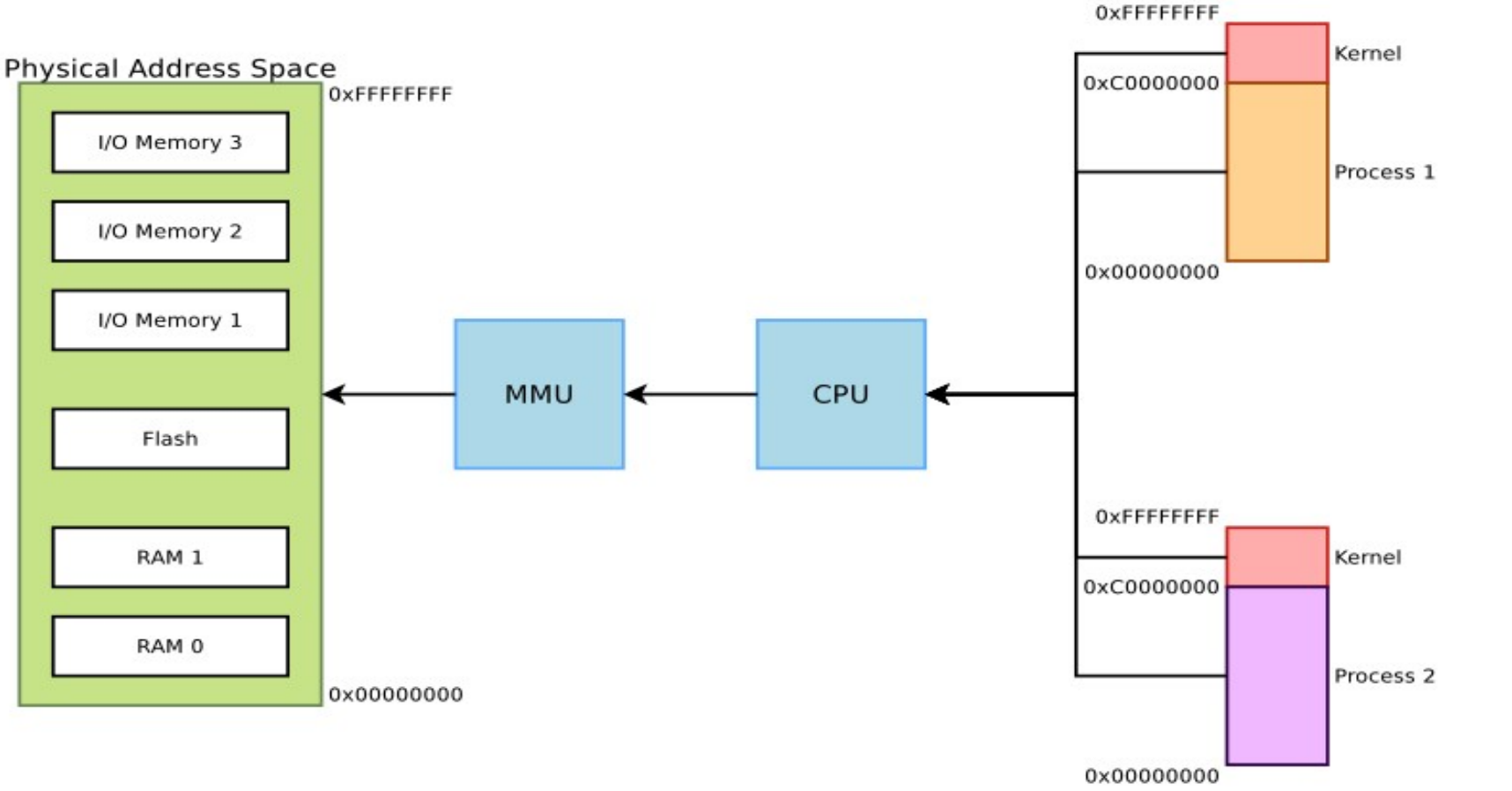
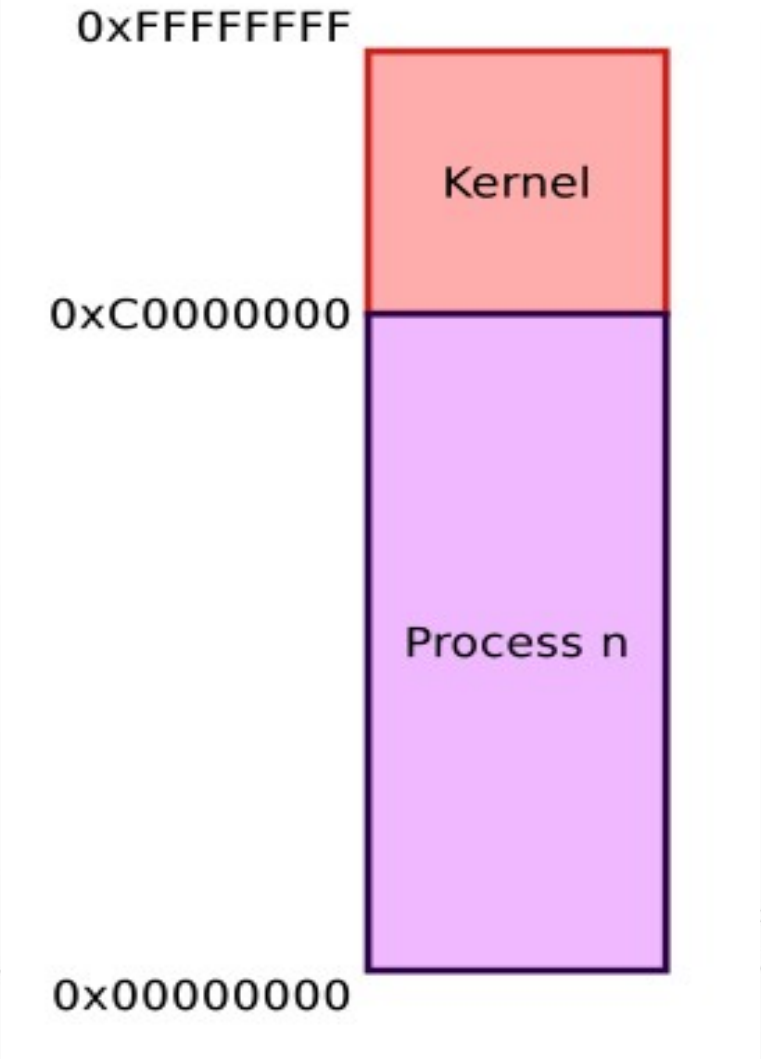

Memory Management

Physical and Virtual Memory



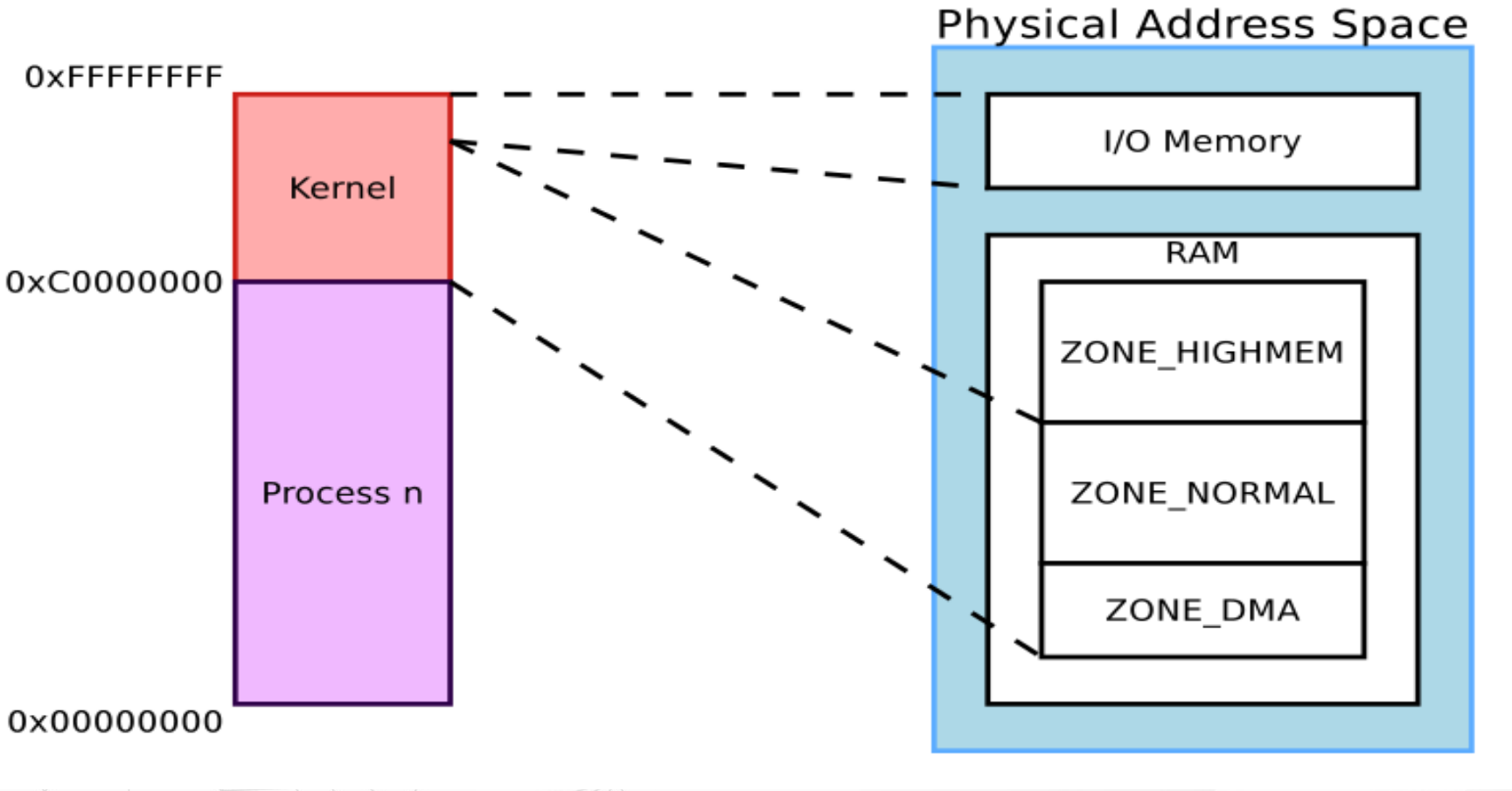
Virtual Memory Organization



- 1GB reserved for kernel-space
- Complete 3GB exclusive mapping

  available for each user space process

Physical / virtual memory mapping



I/O Memory and Ports

Port I/O vs. Memory-Mapped I/O

- MMIO
  - Access with memory instruct
- Port IO
  - Access with I/O instruct

Interrupt

The /proc Interface

- #cat /proc/interrupts

```
           CPU0       CPU1       CPU2       CPU3
  0:        129          0          0          0   IO-APIC-edge      timer
  1:      55747          0          0          0   IO-APIC-edge      i8042
  8:          1          0          0          0   IO-APIC-edge      rtc0
  9:         21          0          6          0   IO-APIC-fasteoi   acpi
 12:    1874181          0         11          0   IO-APIC-edge      i8042
 16:        760          0          0          0   IO-APIC-fasteoi   ehci_hcd:usb1, nouveau
 17:    1335896          0          0          0   IO-APIC-fasteoi   ath9k, snd_hda_intel
 19:      45578          0          0          0   IO-APIC-fasteoi   ata_piix
 21:      25401          0          0          0   IO-APIC-fasteoi   ata_piix
 23:      70598          0          0          0   IO-APIC-fasteoi   ehci_hcd:usb2
 41:          7          0          0          0   PCI-MSI-edge      mei
 42:        113          0          0          0   PCI-MSI-edge      snd_hda_intel
 43:          1          0          0          0   PCI-MSI-edge      eth1
NMI:        803        850       2281        866   Non-maskable interrupts
LOC:    3151539    2486282    3129027    2701622   Local timer interrupts
SPU:          0          0          0          0   Spurious interrupts
PMI:        803        850       2281        866   Performance monitoring interrupts
IWI:          0          0          0          0   IRQ work interrupts
RES:    5727677    1920019    5852607    1977131   Rescheduling interrupts
CAL:        957        938        854        990   Function call interrupts
TLB:     109271      45029      87467      48989   TLB shootdowns
TRM:          0          0          0          0   Thermal event interrupts
THR:          0          0          0          0   Threshold APIC interrupts
MCE:          0          0          0          0   Machine check exceptions
MCP:         90         90         90         90   Machine check polls
ERR:          0
MIS:          0
```

Module

```
static int __init module_test_init(void)
{
    pr_err("%s\n", __func__);
}
module_init(dmatest_init);

static void __exit module_test_exit(void)
{
    pr_err("%s\n", __func__);
}
module_exit(dmatest_exit);

MODULE_AUTHOR("Slash Huang <slash.linux.c@gmail.com>");
MODULE_LICENSE("GPL v2");
```

Module installation

- make **modules_install**
- Installs all modules in **/lib/modules/<version>**
- Module **.ko (Kernel Object)** files, in the same directory structure as in the sources.
- **modules.alias**
  - Module aliases for module loading utilities.
- **modules.dep**
  - Module dependencies
- **modules.symbols**
  - Tells which module a given symbol belongs to

Make module

- Build modules
  - **#make modules**
- Set install patch
  - export **INSTALL_MOD_PATH**=../modules
- Install module to INSTALL_MOD_PATH
  - **#make modules_install**
- Copy modules to rootfile
  - cp -a ../modules/lib/modules/3.x.xx.x/ ~/nfs_root/lib/modules/

Install Module

- Install module
  - # modprob module_name
  - #insmode
- Remove moudle
  - # modprob -r module_name
  - #rmmod

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modprobe depmod

- modprobe
  - /lib/modules/'uname -r'
- depmod
  - creates a list of module dependencies /lib/modules/version

Hardware Module

- http://www.cadtc.com.tw/development-board-and-peripheral-modules/m4.html