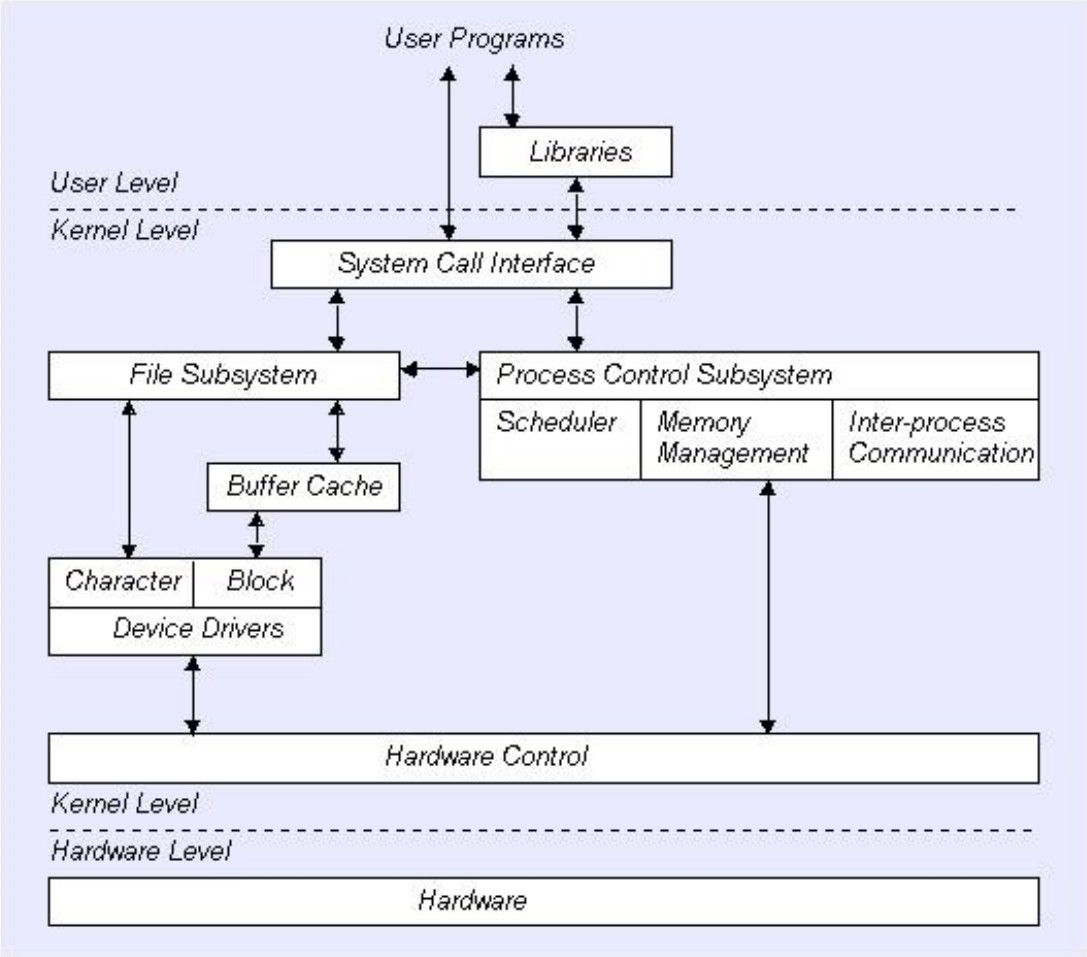
Linux Device Driver

Analog/Digital Signal Interfacing

User Program & Kernel Interface



Note: This picture is excerpted from Write a Linux Hardware Device Driver, Andrew O'Shauqhnessy, Unix world

Loadable Kernel Module(LKM)

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Types of LKM

- Device drivers
- Filesystem driver (one for ext2, MSDOS FAT16, 32, NFS)
- System calls
- Network Drivers
- TTY line disciplines. special terminal devices.
- Executable interpreters.

Basic LKM (program)

- Every LKM consist of two basic functions (minimum)：

```
int init_module(void) /*used for all initialition stuff*/
{
...
}
void cleanup_module(void) /*used for a clean shutdown*/
{
...
}
```

- Loading a module - normally retricted to root - is managed by issuing the follwing command: # insmod module.o

LKM Utilities cmd

- insmod
  - Insert an LKM into the kernel.
- rmmod
  - Remove an LKM from the kernel.
- depmod
  - Determine interdependencies between LKMs.
- kerneld
  - Kerneld daemon program
- ksyms
  - Display symbols that are exported by the kernel for use by new LKMs.
- lsmod
  - List currently loaded LKMs.
- modinfo
  - Display contents of .modinfo section in an LKM object file.
- modprobe
  - Insert or remove an LKM or set of LKMs intelligently. For example, if you must load A before loading B, Modprobe will automatically load A when you tell it to load B.

Common LKM util cmd

- Create a special device file

  % mknode /dev/driver c 40 0

- Insert a new module

  % insmod modname

- Remove a module
- %rmmod modname
- List module

  % lsmod

  Or % more /proc/modules

```
audio                37840   0
cmpci                24544   0
soundcore             4208   4 [audio cmpci]
nfsd                 70464   8 (autoclean)
```

Linux Device Drivers

- A set of API subroutines (typically system calls) interface to hardware
- Hide implementation and hardware-specific details from a user program
- Typically use a file interface metaphor
- Device is a special file

Linux Device Drivers (continued)

- Manage data flow between a user program and devices
- A self-contained component (add/remove from kernel)
- A user can access the device via file name in /dev , e.g. /dev/lp0

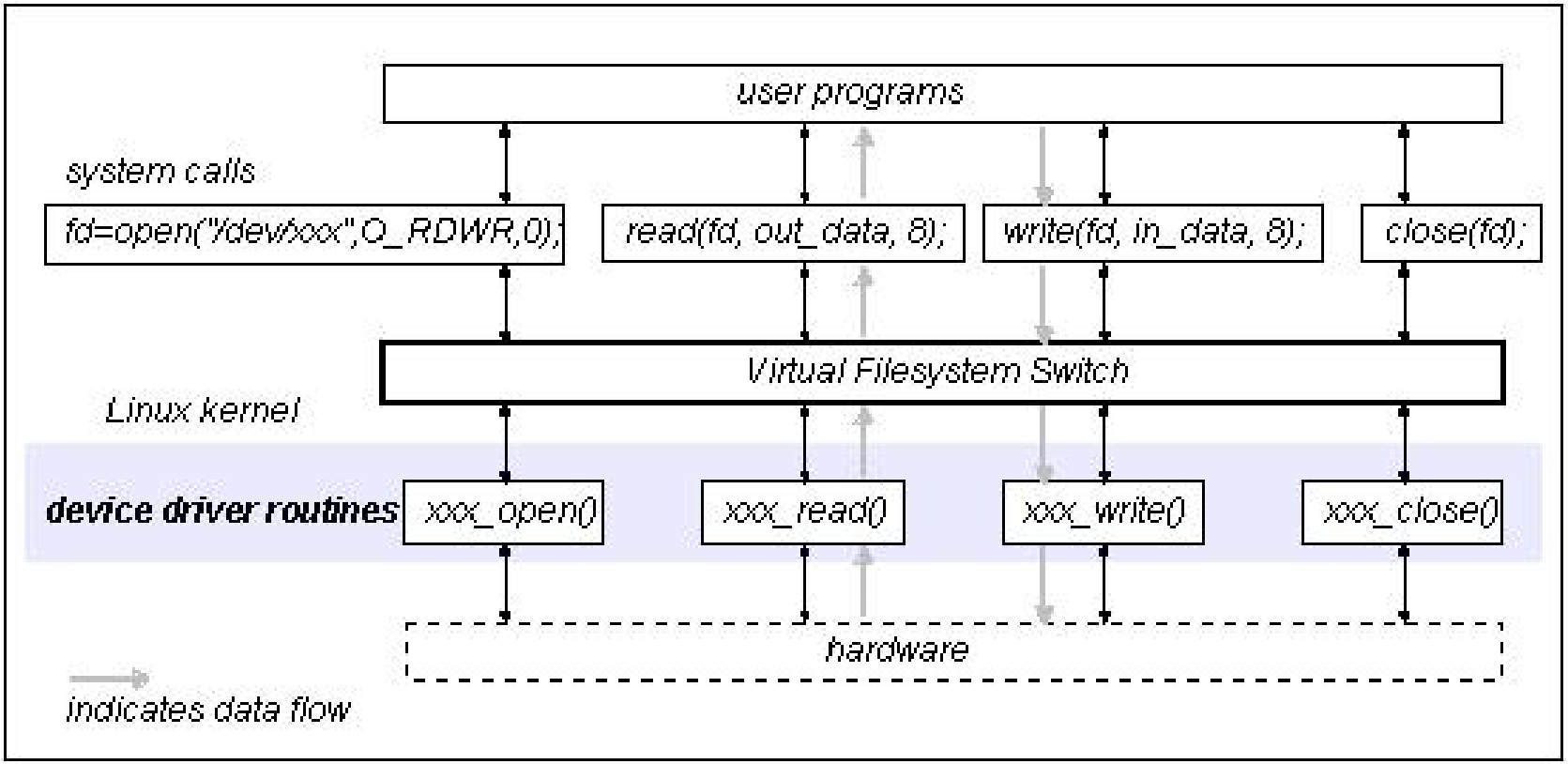
General implementation steps

1. Understand the device characteristic and supported commands.
2. Map device specific operations to unix file operation
3. Select the device name (user interface)
   - Namespace (2-3 characters, /dev/lp0)
4. (optional) select a major number and minor (a device special file creation) for VFS interface
   - Mapping the number to right device sub-routines
5. Implement file interface subroutines
6. Compile the device driver
7. Install the device driver module with loadable kernel module (LKM)
8. or Rebuild (compile) the kernel

Read/write (I/O)

- Polling
- Interrupt based

Device Driver interface



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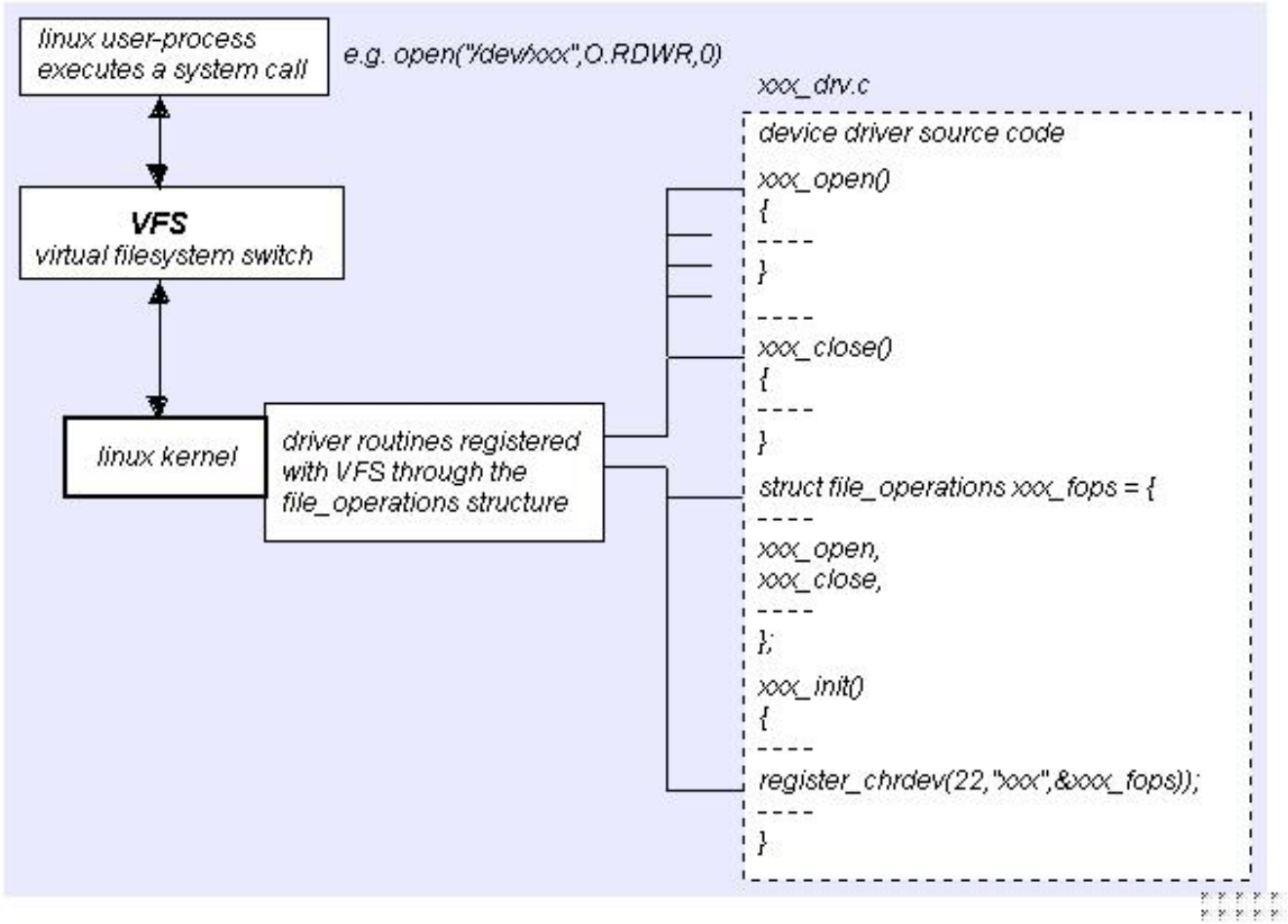
VFS & Major number

- principal interface between a device driver and Linux kernel



File operation structure

- struct file_operations Fops = {
  NULL, /* seek */
  xxx_read,
  xxx_write,
  NULL, /* readdir */
  NULL, /* select */
  NULL, /* ioctl */
  NULL, /* mmap */
  xxx_open,
  NULL, /* flush */
  xxx_release /* a.k.a. close */
- };

- struct file_operations Fops = {
  read: xxx_read,
  write: xxx_write,
  open: xxx_open,
  release: xxx_release, /* a.k.a. close */
  };

Watch out compatibility issue with Linux version

Device special file

- Device number
  - Major (used to VFS mapping to right functions)
  - Minor (sub-devices)
- mknod /dev/stk c 38 0
- ls –l /dev/tty
  - crw-rw-rw- 1 root root 5, 0 Apr 21 18:33 /dev/tty

Register and unregister device

```
int init_module(void) /*used for all initialition stuff*/
{
        /* Register the character device (atleast try) */
        Major = register_chrdev(0,
                                DEVICE_NAME,
                                &Fops);
      :

}
void cleanup_module(void) /*used for a clean shutdown*/

    {ret = unregister_chrdev(Major, DEVICE_NAME);

...
}
```

Register and unregister device

- compile

  -Wall -DMODULE -D__KERNEL__ -DLINUX –DDEBUG -I /usr/include/linux/version.h -I/lib/modules/`uname -r`/build/include

- Install the module

  %insmod module.o

- List the module

  %lsmod

- If you let the system pick Major number, you can find the major number (for special creation) by

  % more /proc/devices

- Make a special file

  % mknod /dev/device_name c major minor

Device Driver Types

- A character device driver (c)
  - Most devices are this type (e.g.Modem, lp, USB
  - No buffer.
- A block device driver (b)
  - through a system buffer that acts as a data cache.
  - Hard drive controller and HDs

Implementation

- Assuming that your device name is Xxx
- Xxx_init() initialize the device when OS is booted
- Xxx_open() open a device
- Xxx_read() read from kernel memory
- Xxx_write() write
- Xxx_release() clean-up (close)
- init_module()
- cleanup_module()