Linux Device Driver
(Module Programming)

Amir Hossein Payberah

payberah@yahoo.com

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- Linux Source
- Kernel Configuration and Compile
- Module Programming

Linux source tree

- Architecture
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- Networking

Architecture

- Linux supports several different architectures.
- The arch directory contains all the platform specific code necessary to implementation low-level system interface.
  - Arm
  - Alpha
  - Athlon
  - i386
  - MIPS
  - SPARC
  - ...

Drivers

- This interaction and controlling of hardware is a small piece of the kernel called drivers.
  - cdrom
  - scsi
  - usb
  - char
  - block
  - sound
  - ...

Filesystem

- In order for the kernel to know how to interact with the filesystem, it must know the structure of it.
  - CramFS
  - DevFS
  - ext2
  - ext3
  - FAT
  - ...

Init

- Init is the initial process of the Linux kernel.
- All initialization of the kernel in handled in this area.
  - Defining all devices
  - Parsing parameters
  - ...
- It is the main process on any UNIX systems.

Interprocess control

- IPC is a method for the kernel to manage processes and allow them to communicate with each other.
  - Message queue
  - Shared memory
  - semaphore

Kernel

- It contains the code to provide the other areas of the kernel with ways to communicate.
- Several functions that are used through other subsystem of the kernel.
  - panic
  - printk
  - softirq
  - ...

Memory management

- It is responsible for keeping track of all system memory and its usage by the kernel.

Networking

- Linux supports several protocol suites in the kernel.
  - 802
  - Appletalk
  - ATM
  - BGP
  - Bluetooth
  - Ethernet
  - IPV4
  - ...

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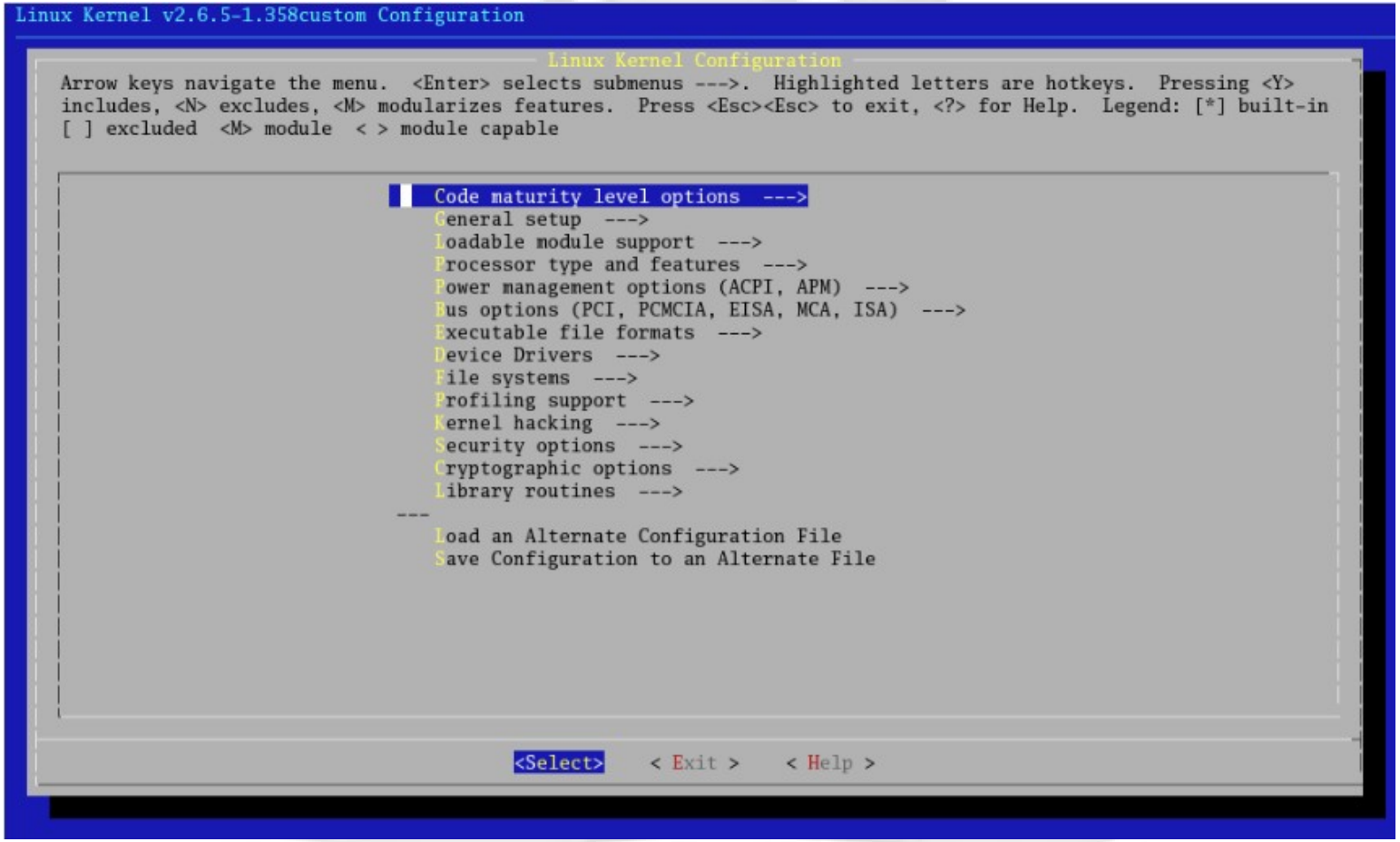
Kernel configuration

- make oldconfig
- make menuconfig
- make xconfig

Kernel configuration



Kernel compile

- Kernel 2.4.x and older
  - make menuconfig
  - make dep
  - make bzImage
  - make modules
  - make modules_install
  - make install

Kernel compile

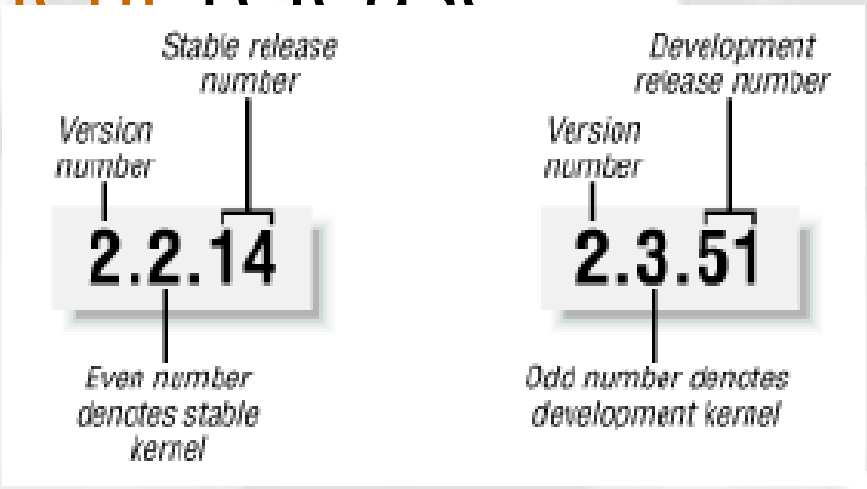
- Kernel 2.6.x
  - make
  - make install
- Clean Kernel Source
  - make clean
  - make mrproper

Kernel version

- Kernel version can be broken down into four section:
  - Major version
  - Minor version
  - Sublevel number
  - Extraversion level

Kernel version

- Even numbered minor version are stable kernels.
- Odd numbered version are development release



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Module vs. Application

- Application
  - An application performs a single task from beginning to end.
  - An application runs in user space.
- Module
  - A module registers itself in order to serve future requests.
  - A module runs in kernel space.
  - The role of a module is to extend kernel functionality.

Hello World

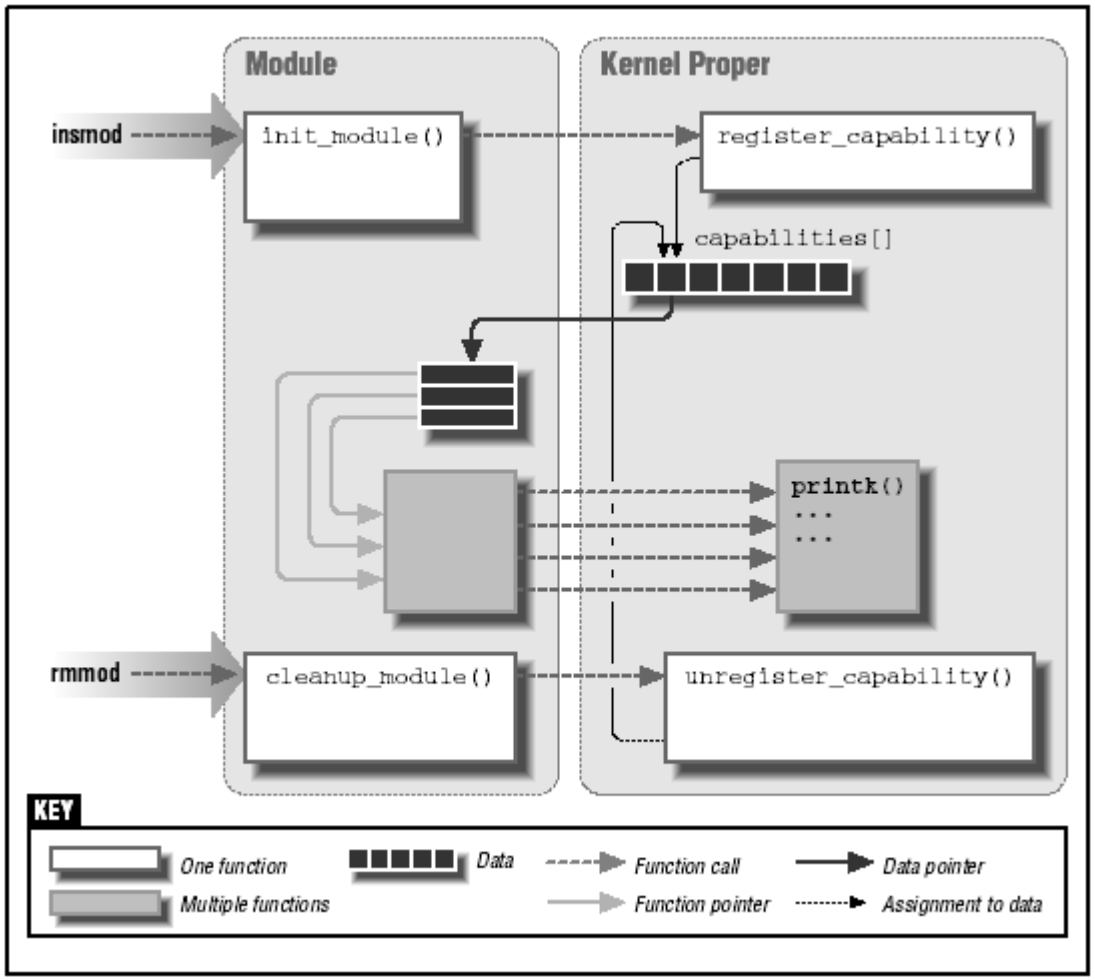
```
#define MODULE
#include <linux/module.h>
//-------------------------------------------------
int init_module()
{
    printk("<1>Hello World ...\n");
    return 0;
}
//-------------------------------------------------
void cleanup_module()
{
    printk("<1>Goodbye ...\n");
}
```

Compiling “Hello World”

```
root# gcc –c hello.c
root# insmod ./hello.o
Hello World ...
root# rmmod hello
Goodbye ...
root#
```

/var/log/messages

Linking a module to the kernel



Module header files

- Because no library is linked to modules, source files should never include the usual header files.
  - include/asm
  - include/linux

Module compile notes

- #define __KERNEL__
  - Much of the kernel specific content in the kernel headers is unavailable without this symbol.
- #define MODULE
  - It must define before #include <linux/module>
- -O
  - gcc doesn't expand inline functions unless optimization is enabled.
- -Wall
  - In order to prevent unpleasant errors.

Makefile

```
KERNELDIR = /usr/src/include
CFLAGS = -D__KERNEL__ –DMODULE
    –I$(KERNELDISR)/include
    -O -Wall
```

Version dependency

- Module’s code has to be recompiled for each version of the kernel that it will be linked to.

Version dependency

- Each module defines a symbol called __module-kernel-version
  - Insmod matches it against the version number of current kernel.
  - The compiler will define this symbol whenever the module's code includes <linux/module.h>
  - This placed in the .modinfo ELF section.
    - ELF (Executable Linking and Format)

Version dependency

- When asked to load a module, insmod follows its own search path to look for the object file (/lib/module).
- In case of version mismatch
  - Force to install (insmod –f).
  - This operation is not safe.

Version macros

- UTS_RELEASE
  - Kernel version : 2.3.48
- LINUX_VERSION_CODE
  - Kernel binary version : 2.3.48 → 131888
- KERNEL_VERSION(major, minor, release)
  - KERNEL_VERSION(2.3.48) = 131888
- They are defined in <linux/version.h>

Kernel symbol table

- It contains the addresses of global kernel items (functions and variables).
  - They are needed to implement modularized drivers.
  - /proc/ksyms
- When a module is loaded, symbol exported by the module becomes part of the kernel symbol table.

Symbol table macros

- EXPORT_NO_SYMBOLS
- EXPORT_SYMBOL(name)
- EXPORT_SYMBOL_NOVERS(name)

Error handling

- If any errors occur when you register utilities, you must undo any registration before the failure.
- Error recovery is sometimes best handled with the goto statement.

Error handling

```
Int init_module()
{
    int err;
    err = register_this(ptr1, “skull”);
    if (err)
        goto fail_this;
    ...
    return 0;
    fail_this: return err;
}
```

Usage count

- The system keeps usage count for every module in order to determine whether the module can be safely removed.
  - /proc/modules

Usage count macros

- MOD_INC_USE_COUNT
  - Increment the count.
- MOD_DEC_USE_COUNT
  - Decrements the count.
- MOD_IN_USE
  - Evaluate to true if the count is not zero

Module configuration

- Parameter values can be assigned at load time by insmod.
  - insmod skull.o ival=666 sval="hello"
- Supported types:
  - Integer : i
  - Long : l
  - String : s
  - Byte : b
  - Shot (two bytes) : h

Module configuration

```
int num = 0;
MODULE_PARM (num, "i");
```

```
char *str;
MODULE_PARM (str, "s");
```

```
int array[4];
MODULE_PARM (array, "2-4i");
```

Question?