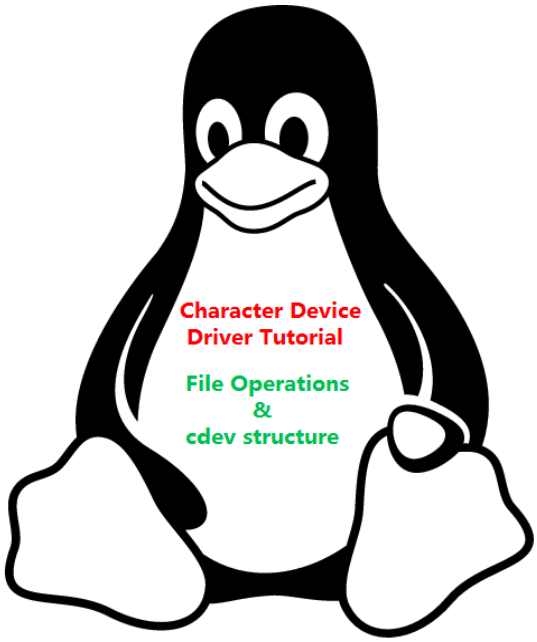
LINUX DEVICE DRIVER AND KERNEL PROGRAMMING

PREREQUISITE : C and Linux Systems Programming

CH1: AN INTRO. TO DEVICE DRIVERS

- Role of the Device Drivers
- Splitting the kernel
- Classes of devices and modules
- Kernel Architecture or Model



CH2: BUILDING AND RUNNING MODULES

- Types of Modules in the kernel
- Writing Your first kernel module
- Module Related Commands
- Kernel Module vs Applications
- Compiling Modules
- Loading and Unloading Modules
- Module Parameters
- Modules and Exporting Symbols

Hands-On Assignments

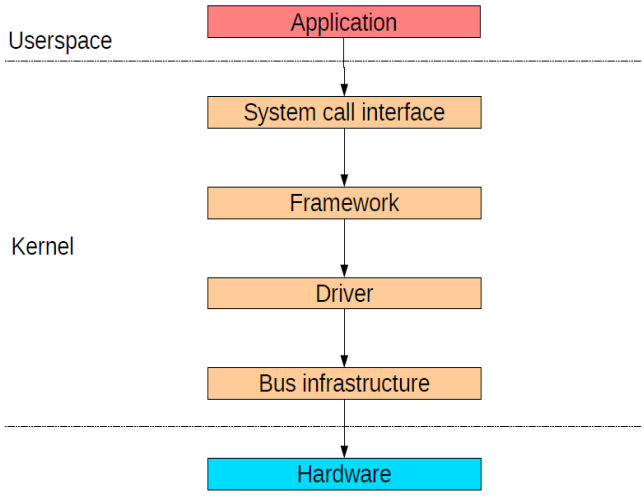
Lab1: Simple Hello Linux Kernel Module.

Lab2: Write a module that can take an integer parameter when it is loaded, It should have a default value when none is specified.

Lab3: Write a pair of modules where the second one calls a function in the first one.

CH3: CHARACTER DEVICE DRIVERS

- Major and Minor Numbers
- The Internal Representation of Device Numbers
- Allocating and Freeing Device Numbers
- File Operations Data structure
- Driver methods and Function Pointers
- Char Device Registration
- The Cdev Structure
- The inode Structure
- The file Structure
- Manual Creation of Device Files
- Automatic Creation of Device Files



Hands-On Assignments

Lab1: Print the major and minor numbers when Registering by Static or Dynamic method.

Lab2: Implement a open,write,read and close entry point.

Lab3: Print the major and minor numbers when the device is Opened and keep track of the number of times it has been opened since loading, and print out the counter every time the device is opened.

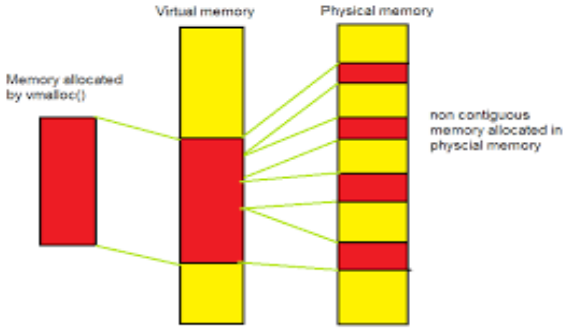
Lab4: Modify the previous driver so that each opening of the device allocates its own data area, which is freed upon release. Thus data will not be persistent across multiple opens.

Lab5 : Implement a lseek entry point and Keeping track of file position.

Lab6: Dynamical Node Creation,Adapt the previous dynamic registration driver to use udev to create the device node on the fly.

CH4: MEMORY ALLOCATION TECHNIQUE

- The Real Story of kmalloc
- The Flags Argument
- __get_free_pages
- Memory zones
- vmalloc and Friends
- Memory caches

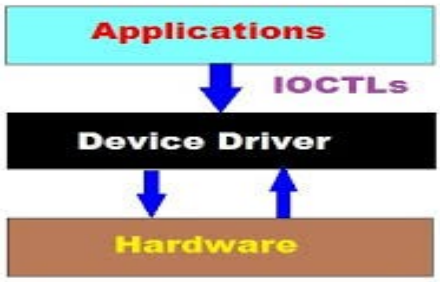


Hands-On Assignments

Lab1:Testing Maximum Memory Allocation ,using kmalloc()
Lab2:Testing Maximum Memory Allocation ,using __get_free_pages().
Lab3: Testing Memory Allocation,using vmalloc().
Lab4 :Memory cachesExtend your chararcter driver to allocate the driver's internal buffer by using your own memory cache.Make sure you free any slabs you create.

CH5: ADVANCED CHAR DRIVER OPERATIONS

- Inpout/Output Control (ioctl)
- User space, the ioctl system call
- The ioctl driver method
- Choosing the ioctl Commands
- Using the ioctl Argument

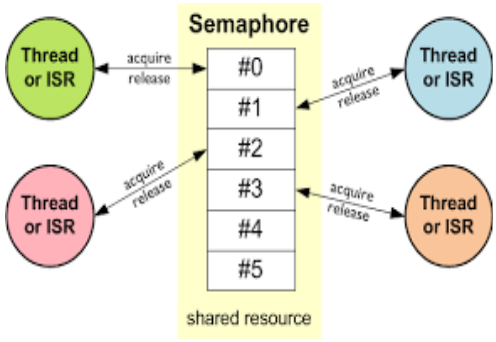


Hands-On Assignments

Lab1 : Implement a ioctl entry point along with read and write entry point.
Lab2 : Implement read and write entry point using ioctl command.
Lab3 : Write a character driver that has three ioctl commands: a)Set the process ID to which signals should be sent. b)Set the signal which should be sent. c)Send the signal.

CH6: CONCURRENCY AND RACE CONDITION

- Concurrency and its Managements
- Semaphores and Mutexes
- Linux Semaphore Implementation
- Introduction to the Semaphore API
- Spinlocks Implementation
- Introduction to the Spinlock API
- Spinlocks and Atomic Context



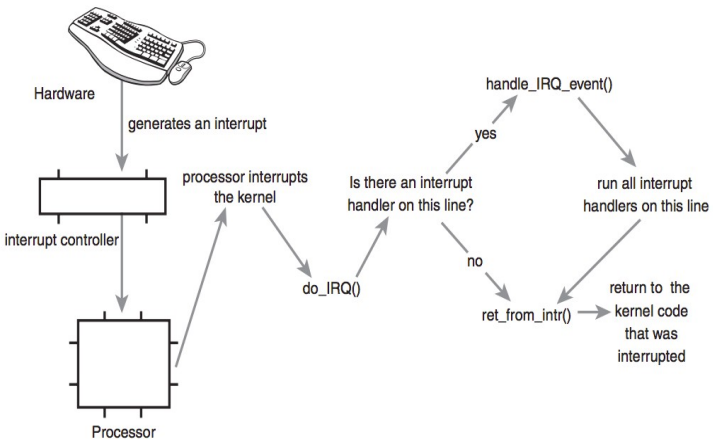
Hands-On Assignments

Lab1: Mutex Contention -Write three simple modules where the second and third one use a variable exported from the first one.The second (third) module should attempt to lock the mutex and if it is locked, either fail to load or hang until the mutex is available.

Lab2: Sempahore Contention -Now do the same thing using semaphores .

CH7: INTERRUPT AND INTERRUPT HANDLING

- The Definition and Role of Interrupt
- Installing an Interrupt Handler
- The /proc Interface
- Implementing a Handler
- Handler Arguments and Return Value
- Installing a Shared Handler



Hands-On Assignments

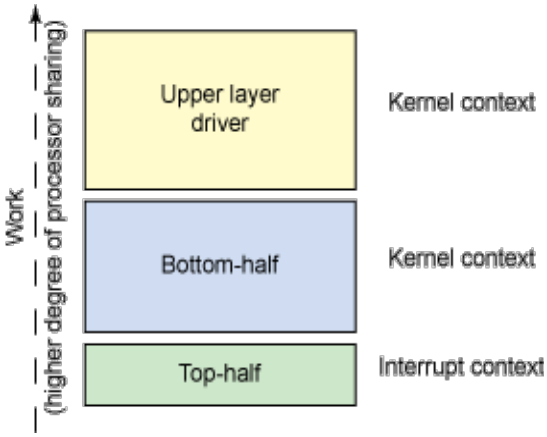
Lab1: Write a module that shares its IRQ with your network card. You can generate some network interrupts either by browsing or pinging.

Lab2: Extend the previous solution to construct a character driver that shares every possible interrupt with already installed handlers.

Lab3: Mutex Unlocking from an Interrupt. Modify the simple interrupt sharing lab to have a mutex taken out and then released in the interrupt handler.

CH8: TIME, DELAY AND DEFERRED WORK

- Top and Bottom Halves
- Tasklets and Workqueues Mechanisms
- Measuring Time Lapses
- Using the jiffies Counter
- The Timer API



Hands-On Assignments

Lab1: Program based on Kernel Timer API

Lab2: Program based on Jiffies and HZ

Lab3: Program based on Taklet API

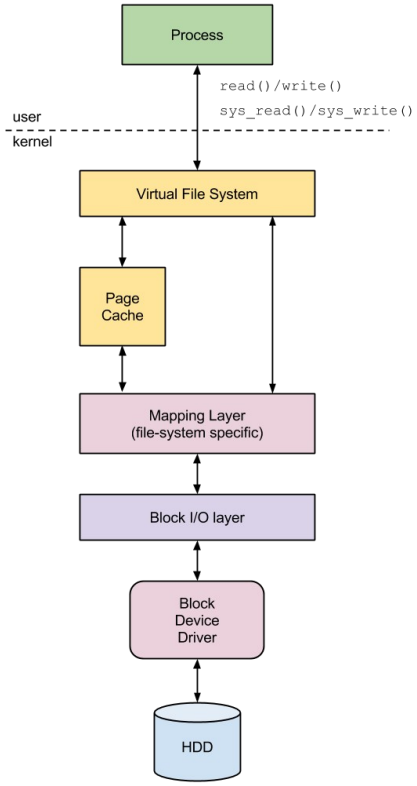
Lab4: Prgram based on Workqueue API

Lab5: Write a driver that puts launches a kernel timer whenever a write to the device takes place. Pass some data to the driver and have it print out. Have it print out the current->pid field when the timer function is scheduled, and then again when the function is executed.

Lab6: Write a module that launches a periodic kernel timer function; i.e., it should re-install itself.

CH9: FUNDAMENTALS OF BLOCK DEVICE DRIVER

- Block drivers Definitions.
- Block drivers Registration.
- Block device operations.
- Linux Block I/O Layer
- I/O Schedulers
- Block Driver Data Structures and Methods
- How to handle block devices



Hands-On Assignments

Lab1: Registering and unregistering a simple Block Driver to get Major number.

CH10: IMPLEMENTATION OF RAMDISK DEVIVE DRIVER

- RAMDISK-based block device driver
- Using the RAMDISK block device
- Driver registration
- Obtaining a gendisk object
- Implement the driver's methods
- Request Queue & Handle the request queue

Hands-On Assignments

Lab1: Write a simple Block driver program to read (and/or write) from the node, using the standard I/O functions (open(), read(), write(), close() .After loading the module with insmod use this program to access the node.

Lab2: Mountable Read/Write Block Driver, Extend the previous exercise in order to put or create an ext3 or ex4 file system on your Block device.

Lab3: Write a program to implement a ram disk device and make it into many partition like systems Hard disk and perform read() , write() operation through block driver vertical.

CH11: UNDERSTANDING PARTITIONING OF BLOCK DEVICES

- Partitioning a Block Device
- Sector,Cylinder and Head
- Structure of a generic MBR
- Partition Table
- The Bootstrap Code Area/Bootloader
- MBR – Partition Table Entries
- Boot Record Signature/Magic Number
- Creating a RAM Block Device

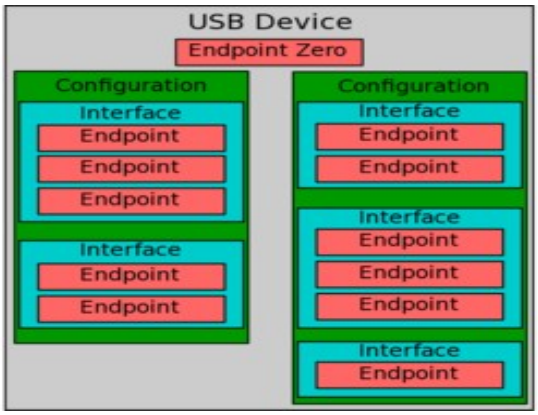
Structure of a generic MBR			
Offsets within sector		Length (in bytes)	Description
Dec	Hex		
000 - 445	000 - 1BD	446	Bootstrap Code Area
446 - 509	1BE - 1FD	64	Partition Table
510 - 511	1FE - 1FF	2	Boot Record Signature

Hands-On Assignments

Lab1: Write a program to implement a ram disk device and make it into many partition like systems Hard disk and perform read() , write() operation through block driver vertical.

CH12: UNDERSTANDING USB DEVICE DRIVER

- USB Device Basics
- Types of USB Device Drivers
- USB Subsystem & Verticals
- USB Protocol & Device Layout
- Defferents types of data transfers
- USB and Sysfs Command
- USB Request Block
- Registering a USB Driver through Horizontal Layer



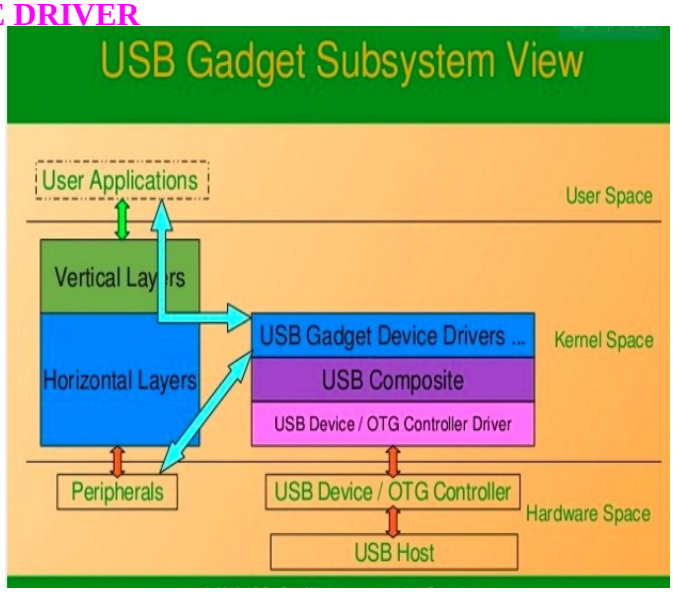
Hands-On Assignments

Lab1:Installing a and writing a simple USB device driver.The driver should register itself with the USB sub-system upon loading and unregister upon unloading.

Lab2: Write a USB device driver to print out information abot configuration , interfaces and endpoint for a registered usb device.

CH13: UNDERSTANDING USB GADGET DEVICE DRIVER

- Linux USB Gadget & Host Drivers
- USB Gadget Driver Mechanism
- USB Host Driver Mechanism
- USB Core & Hot Plug n Play
- USB Gadget Transfer Functions
- Integration with a Vertical
- Types of USB Device Drivers



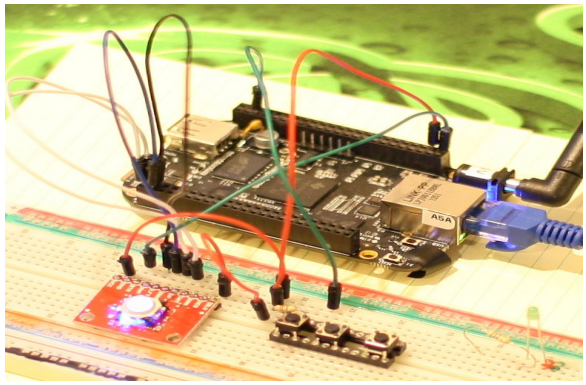
Hands-On Assignments

- First take at a USB Gadget Driver
- Getting down to the hardware of BBB
- Creating Interface for USB Gadget Driver
- Creating Enfpoint for USB Gadget Driver

CH14: CREATING BEAGLEBONE as USB GADGET DEVICE DRIVER

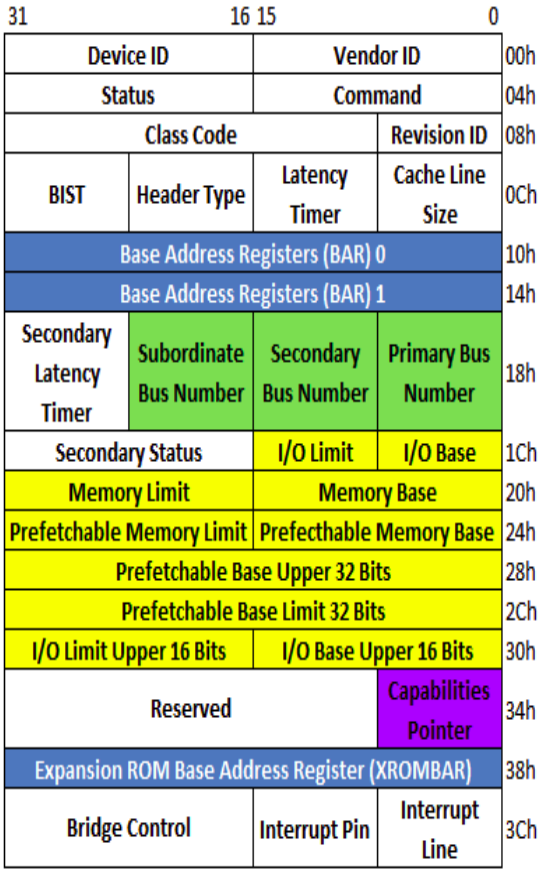
- Register a composite driver
- Structure of usb_composite_driver
- Structure of struct usb_function
- Creating Beaglebone BBB as a USB I/O Device

- LoopBack USB Gadget Device Driver
- Getting down to the hardware of BBB
- Creating Multiple Interface for USB Gadget Driver
- Controlling using custom USB Host Driver & App
- BBB as standard USB Devices
- Controlling BBB Gpio LED through USB Drivers
- Creating as standard USB storage device



CH15: PCI DEVICE DRIVER AND ITS ROLE

- Understanding the x86 processor bus: PCI
- PCI Core & Programming the PCI
- Finding & Interacting with a PCI Device
- PCI Bus, Device and Function numbers
- Registering & Finding a PCI device
- Mapping & Accessing the PCI device regions
- Accessing the Configuration Space
- Accessing the I/O and Memory Regions
- Enabling the PCI Device



Hands-On Assignments

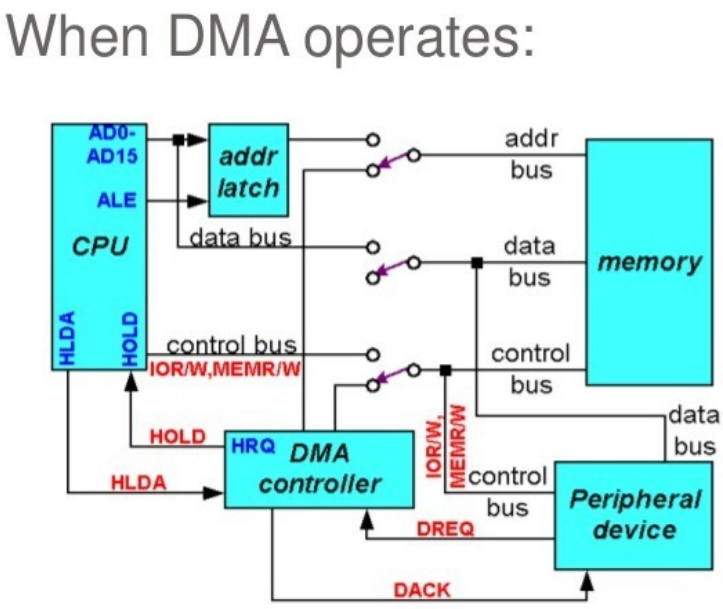
Lab1:Registering the driver with the PCI subsystem.

Lab2: Write a module that scans your PCI devices, and gathers information about them.For each found device, read some information from its configuration register.Fields you may wish to obtain could include:
PCI_VENDOR_ID,
PCI_DEVICE_ID,
PCI_REVISION_ID,
PCI_INTERRUPT_LINE,PCI_LATENCY_TIMER,
PCI_COMMAND.

Lab3: Write a Character based PCI driver to find Information about IRQ Line,Memory region,I/O region,configuration region,prefetchable and non-prefetchable region in BAR.

CH16: MEMORY MAPPING AND DMA

- What memory is DMA'able
- DMA addressing limitations
- Types of DMA mappings
- DMA Direction



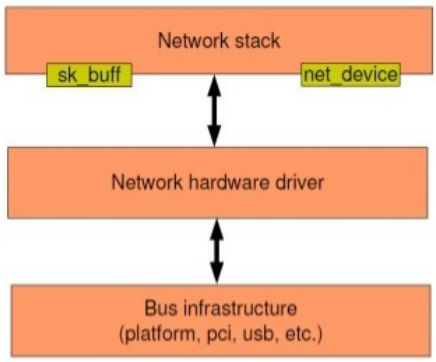
Hands-On Assignments

Lab1: Write a module that allocates and maps a suitable DMA buffer, and obtains the bus address handle.

Do this in three ways:
(a)Using dma_alloc_coherent(),
(b)Using dma_map_single(),
(c)Using a DMA Pool.

CH17: BASIC NETWORK DEVICE DRIVER

- Registering the Network Driver
- Buffer Management with skbuffs
- Packet Transmission & Reception
- Reception using interrupt and poll
- Start the network interface's transmit Queue
- Other network operations including statistics



Hands-On Assignments

Lab1: Building a Transmitting Network Driver,
Module to include a transmission function.
Lab2: Adding Reception, Extend your transmitting
device driver to include a reception function.

CH18: ADVANVED NETWORK DEVICE DRIVER

- Registering with the Linux low level bus interface subsystem
- Allocating interface descriptor block (net_device)
- Device specific structure and initializing media specific fields
- Getting device specific structure object pointer
- Enabling Network interface card
- Getting the Device resources (MMIO and PMIO)
- Getting device MAC address
- Initialization of device methods in the net_device
- Registering net_device object with the kernel
- Registering the interrupt handler (ISR)
- Allocating Rxring and Txring
- Initializing the hardware (network interface card)

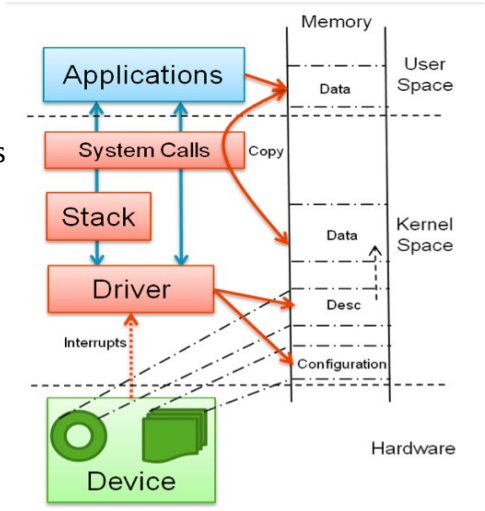


Figure 1: Kernel space network driver

Hands-On Assignments

Lab3: Writing the PCI based Network Driver for NIC(Network Interface Card) .
Programming the Network Device Registers, Implementing the Transmission & Reception with the actual device(NIC) and Setting up the network across computers.

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