LINUX SYSTEMS PROGRAMMING, PORTING & BOARD BRINGUP AND KERNEL PROGRAMMING

Prerequisite : Advanced C Programming

MODULE 1: LINUX SYSTEM & IPC PROGRAMMING

CH1: INTRODUCTION TO UNIX/LINUX

- Histoty of Unix/Linux
- Linux Layered Architecture
- Type of Kernels
- Micro and Monolithic kernel
- Different types of kernel structure
- Linux Bootup Sequence

CH3: FILE SYSTEM MANAGEMENTS

- File Systems – VFS
- File Systems Layouts
- Super Block & Inode Block
- Inode block Structure
- Device Special Files
- Types of File
- File descriptor table
- System calls Sequence
- System Vs Function Calls
- File related System Calls
- open(),read(),write(),close()
- stat(),lstat(),dup() etc.

CH5: FILE LOCKING PROGRAMMING

- File Control Operations
- Types of File Locking
- Advisory and Mandatory File locking
- fcntl() and flock()calls

CH7: THREADS AND MULTI-THREAD

- Threads on different O.S
- Why Threads in Linux
- Threads Vs Process
- Thread APIs
- Creation of Multithreading
- Performig Multiple operations using multi-threading

CH9: SIGNALS VS. INTERRUPTS

- Sources of Signals
- Diffrents type of Signals
- Actions of Signals
- Receiving a Signal
- Handling a Signal
- Signal System Calls

CH2: PROCESS MANAGEMENTS

- Program and Process
- Process Control Block (PCB)
- States Of Process
- Mode of Execution
- User mode and Kernel mode
- Context Switching
- Scheduling & Priority

CH4: PROCESS RELATED PROGRAMMING

- Process Creation by fork() amd vfork()
- Why fork() not vfork()
- Creation and Destroying Zombie Process
- Creation of Orphan Process
- wait() and waitpid() calls
- exit() and exec() ,sleep() calls
- Creating , synchronizing and performing multiprocessing concepts
- Setting and changing nice value and Prority no.

CH6: MEMORY MANAGEMENTS AND MMU

- Memory Policy and Hirarchy
- Memory allocation Technique
- Physical memory &Virtual Memory
- Paging & Demand paging
- Memory Mapping using TLB
- Swap in & Swap out
- Internal & External Fragmentation

CH8: PRIMITIVE INTERPROCESS COMM (IPCS)

- PIPES
- Creation of Half and Full-duplex
- Half and Full-duplex communication
- FIFO

CH10. SYSTEMS V IPCs

- Shared Memory
- Message Queues
- Semaphores

CH12: NETWORKANDSOCKET PROGRAMMING

- Description of ISO/OSI Model
- Types of IP Classes (A,B,C,D and E)
- Network addresses and Host addresses
- UDP Connectionless Oriented Socket
- TCP/IP Connection Oriented Socket

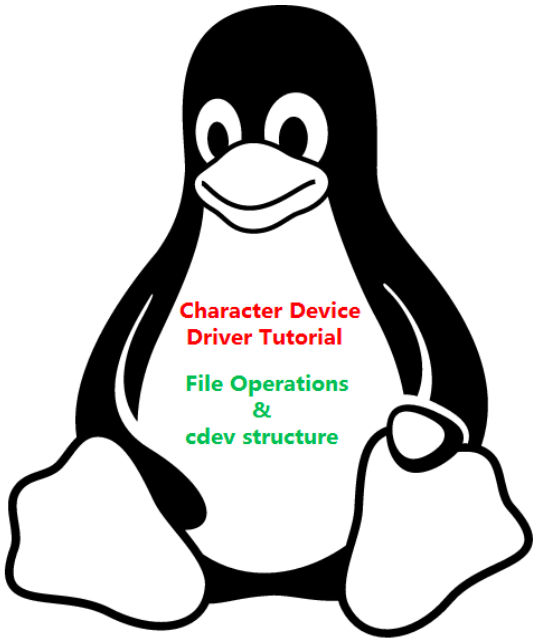
CH11: USER AND DAEMON PROCESS

- Creating a Daemon Process
- Characteristics of a Daemon
- Writing and Running Daemon
- Iterative Server-Client Programming
- Concurrent Server- Client Programming
- One Server and Many client Programming

MODULE 2: LINUX KERNEL & CHAR DRIVER 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

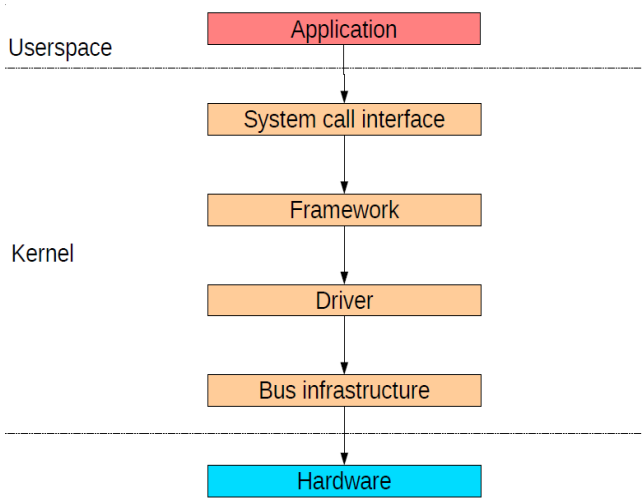
Lab1: Simple Hello Linux Kernel Module.

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.

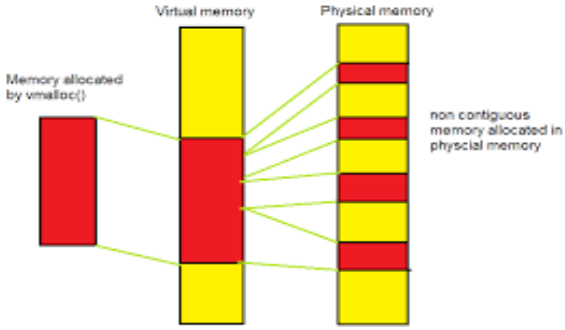
Lab4: Modify the previous driver so that each opening of the device allocates its own data area, which is freed upon release. Thus data will not be persistent across multiple opens.

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

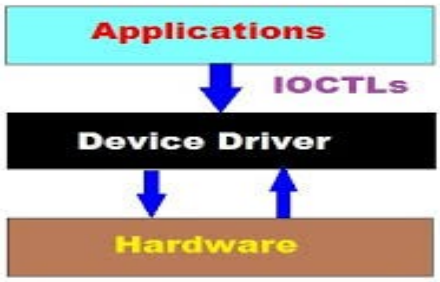


Hands-On Assignments

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

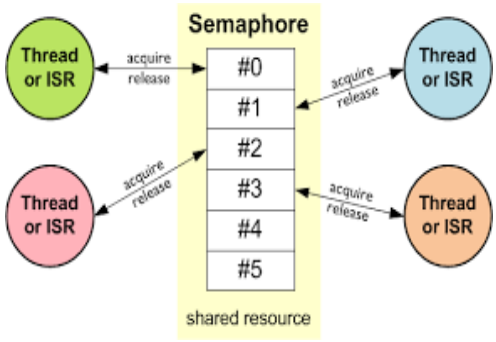


Hands-On Assignments

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



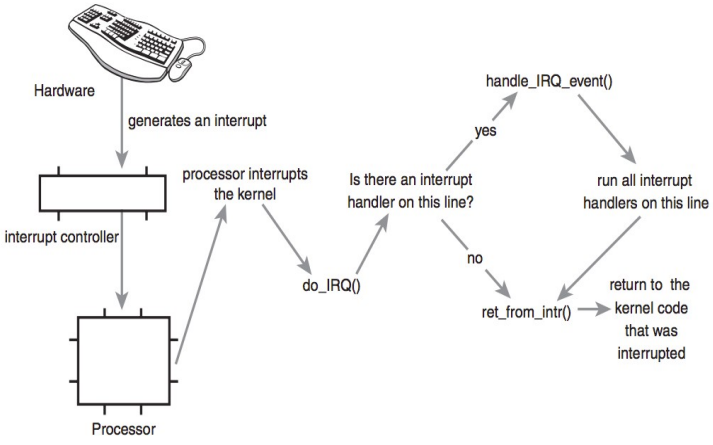
Hands-On Assignments

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

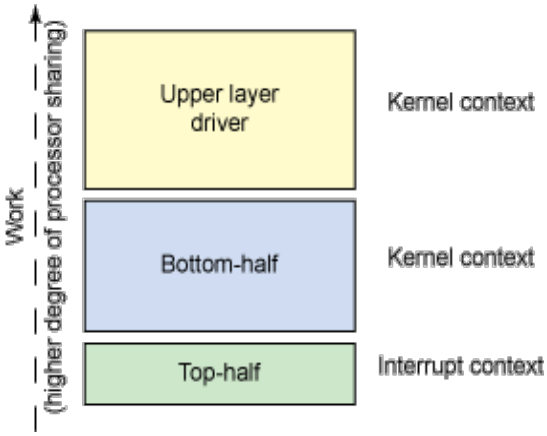


Hands-On Assignments

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.

MODULE 3: BOARD BRINGUP & POARTING ON BEAGLEBONE

CH1. Genesis of Linux project : : Introduction

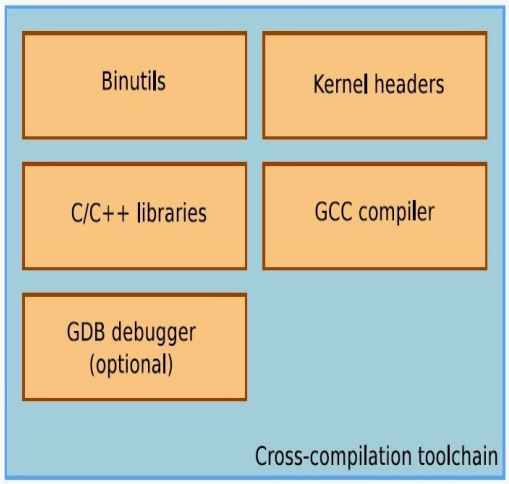
- Element 1:Tool chain (Air)
- Element 2:Boot loader (Earth)
- Element 3:Kernel (Fire)
- Element 4:User space (Water)

CH 2: Toolchain Setup : : Introduction to Toolchain

- What is Toolchain.
- Toolchain Components
- Building Toolchain
- Build Systems for Toolchain
- Toolchain Setup Environment
- Toolchain compilation and usage

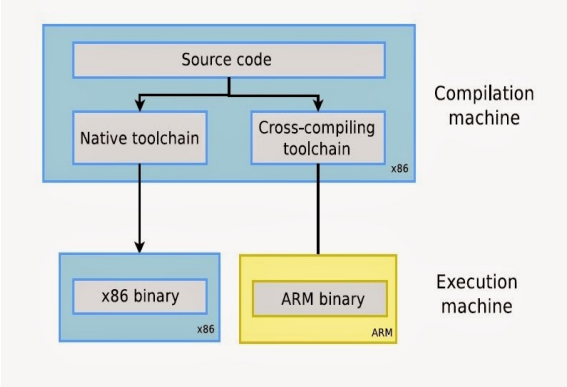
CH 3: Bootloader Compilation : : Introduction to Bootloader

- What is Loader
- What is Bootloader
- 1st and 2nd Stage Bootloader
- U-Boot Bootloader Porting on New
- U-Boot Commands Lists
- Bootloader Cross-Compilation
- Downloading on Target board
- Bootloader commands and usage,
- Bootloader code customization, U-Boot.
- U-Boot Image for Target Board



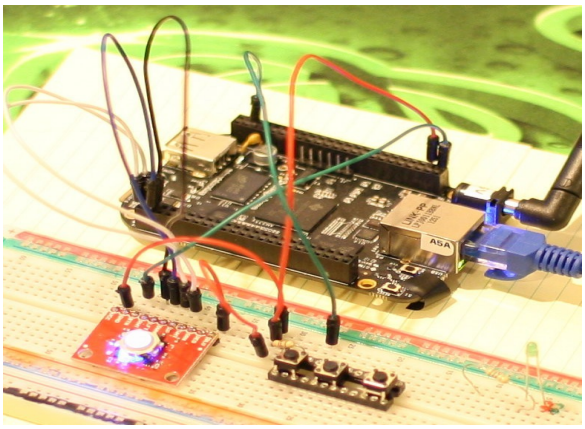
CH 4: Kernel Configuration : : Linux kernel Cross Compilation

- Browsing Linux Kernel Source
- Visualizing Kernel Source Tree
- Cross-Compilation of Kernel Source
- Generating Kernel Image
- uImage,zImage,dtb
- uImage on Target Board
- Application development and Cross Compilation



CH 5: Porting Linux kernel,U-boot images on Target board

- Sd Card partitioning
- Wrtting uImage,U-boot.bin into Sd cards
- Building the Embedded Board Using SD-Card for rootfs
- Configuring NFS and using rootfs over NFS
- Building the Embedded Board Using NFS



CH 6: Programming for Target board BBB

- Testing User Application program for BBB
- Wrtting GPIO Device Drivers Program for BBB
- Registering Interrupt handler on BBB

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