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## Linux Device Drivers and Kernel Programming

### Abstract

The course teaches attendees how device drivers work with the Linux kernel, how to compile and load drivers, how to debug drivers, as well as other essential topics. The course progresses through a number of topics. Each topic is presented along with a supporting laboratory exercise before moving on to the next topic.

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### Target Audience

The course is designed for software engineers who are new to Linux device drivers. Attendees should have experience with C, be able to perform basic UNIX commands, and have some experience with the basic Gnu tools of gcc, gdb, and make.

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### Highlights

- Linux Drivers Overview
  - Character Drivers
  - Accessing Hardware
  - Accessing PCI Hardware
  - Kernel Programming
  - USB Drivers
  - Handling Interrupts
  - Block Drivers
  - File System Modules
  - Kernel debugging & Profiling overview
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### Duration

5 Days

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### Course Materials

The workshop materials include a comprehensive student workbook. The workbook contains all of the slides used in the course as well as hands-on lab exercises.

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### Course Workshop and Set-up

The workshop makes use of standard PC's with a desktop Linux distribution for development. The course will make use of [Linux Device Driver Kit \(LDD Kit\)](#) and PC's and PC devices to demonstrate examples.

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## Day1:

### **Introduction to Linux**

- Introduction to linux operating system (OS)
- Introduction to linux open source software (OSS)
- W's of Kernel
  - ✓ Micro Kernel vs Monolithic kernel
- Linux Architecture
  - ✓ User Space, System call interface, Kernel Space, hardware
- Linux Kernel Startup
  - ✓ Linux kernel Build system
- Linux Kernel configuration
  - ✓ make config, make menu config, make xconfig
- Linux Kernel compilation
  - ✓ building kernel
- Linux Kernel Subsystem
  - ✓ SCHED, MM, VFS, NET, IO, IPC
- Linux Applications
  - ✓ Shell, terminal/console, Editor, Compiler...
- Linux usage Basics
  - ✓ Root & System directories, shell basics,
  - ✓ file basic & related commands
  - ✓ user basics & related commands
  - ✓ file accesses permissions
  - ✓ system & help info

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## Introduction to Linux Drivers

- W's of Linux Drivers
  - ✓ What is driver?
  - ✓ Why we need a driver?
  - ✓ Roles of Linux driver.
- Ecosystem of Linux Drivers
  - ✓ Char, Block, file system, network drivers
- Drivers, Modules, and the "Device" Drivers
  - ✓ module commands, listing, loading, unloading, auto-loading modules
- /proc
- /sys
- The First Driver
  - ✓ module\_init
  - ✓ module\_exit
  - ✓ printk
  - ✓ Makefile

## Day2:

### Character Drivers

- Name vs Number
  - ✓ Major, Minor numbers
  - ✓ MAJOR(dev\_t). MINOR(dev\_t), MKDEV(int major, int minor)
- Registration & the Cleanups
- Kernel Data Structures & File Operations

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- Linux Device Model & Bus Architectures
- bus, class, device

## Low-level Accesses

- ✓ various address space in linux
- role of memory manager in linux
- accessing memory in kernel space
- accessing device or hardware
  - ✓ memory, registers
- low level access in drivers
  - ✓ malloc, vmalloc, vfree, get\_free\_pages, free\_pages, ioremap, iounmap, ioread, iowrite
  - ✓ inb, inw, inl, outb, outw, outl

## Day3:

### Embedded Device Bus Drivers

- PCI
  - ✓ PCI vs ISA, plug n play, H/w addressing,
  - ✓ PCI core, pci drivers
  - ✓ pci device configuration space
  - ✓ pci driver registration and unregistration
  - ✓ pci probing
- I2C Drivers
- SPI Drivers

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## Kernel 'Embedded C' Programming

- Achieving Concurrency
  - ✓ Mutex, semaphores, spin locks, atomic variables, wait queues
- Keeping time
  - ✓ tick, HZ, jiffies, TSC
- Providing delays
  - ✓ time\_before(), time\_after(), ndelay(), udelay(), mdelay()
- Timer control
- Kernel timers
- Tasklets
- Work queues

## Day4:

### USB Drivers

- Device & Driver Layout
  - ✓ Config, Interface, Endpoint
- USB Core
- Driver & Device Registration
  - ✓ Hot Plug-ability
- URB & its Functionalities

### Interrupts

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- Interrupts & IRQs
- Soft IRQs
- Exceptions
- Top & Bottom Halves

## Day5:

### **Block Drivers**

- Driver & Device Registration
- Kernel Data Structures & Device File Operations
- Request Queue Ecosystem

### **File System Modules**

- Virtual File System
- The Five Operation Sets
  - ✓ File System level, Super block level, inode level, file level, buffer cache level

### **Kernel Debugging and Profiling**

- Kernel Debugging tools and techniques
- gdb, kdb, kgdb