Training: The Linux Foundation
LFD430 Developing Linux Device Drivers

THE LINUX FOUNDATION AUTHORIZED TRAINING PARTNER

TRAINING GOALS:

This 4 days course will teach you how to develop device drivers for Linux systems, grounded with a basic familiarity and understanding of the underlying Linux kernel. You will also learn about the different types of Linux device drivers as well as the appropriate APIs and methods through which devices interface with the kernel.

During this course you will learn:

- The different kinds of device drivers used in Linux
- The appropriate APIs through which devices (both hardware and software) interface with the kernel.
- Necessary modules and techniques for developing and debugging Linux drivers
- And more.

The information in this course will work with any major Linux distribution.

CONSPECT:

- Introduction
  - Objectives
  - Who You Are
  - The Linux Foundation
  - Linux Foundation Training
  - Linux Distributions
  - Platforms
  - Preparing Your System
  - Using and Downloading a Virtual Machine
  - Things change in Linux
  - Documentation and Links
  - Course Registration
- Preliminaries
  - Procedures

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    - Kernel Versions
    - Kernel Sources and Use of git
    - Rolling Your Own Kernel
    - Hardware
    - Staging Tree
- How to Work in OSS Projects **
    - Overview on How to Contribute Properly
    - Stay Close to Mainline for Security and Quality
    - Study and Understand the Project DNA
    - Figure Out What Itch You Want to Scratch
    - Identify Maintainers and Their Work Flows and Methods
    - Get Early Input and Work in the Open
    - Contribute Incremental Bits, Not Large Code Dumps
    - Leave Your Ego at the Door: Don’t Be Thin-Skinned
    - Be Patient, Develop Long Term Relationships, Be Helpful
- Device Drivers
    - Types of Devices
    - Mechanism vs. Policy
    - Avoiding Binary Blobs
    - Power Management
    - How Applications Use Device Drivers
    - Walking Through a System Call Accessing a Device
    - Error Numbers
    - printk()
    - devres: Managed Device Resources
    - Labs
- Modules and Device Drivers
    - The module_driver() Macros
    - Modules and Hot Plug
    - Labs
- Memory Management and Allocation
    - Virtual and Physical Memory
    - Memory Zones
    - Page Tables
    - kmalloc()
    - __get_free_pages()

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- vmalloc()
- Slabs and Cache Allocations
- Labs

- Character Devices
  - Device Nodes
  - Major and Minor Numbers
  - Reserving Major/Minor Numbers
  - Accessing the Device Node
  - Registering the Device
  - udev
  - dev_printk() and Associates
  - file_operations Structure
  - Driver Entry Points
  - The file and inode Structures
  - Miscellaneous Character Drivers
  - Labs
- Kernel Features
  - Components of the Kernel
  - User-Space vs. Kernel-Space
  - What are System Calls?
  - Available System Calls
  - Scheduling Algorithms and Task Structures
  - Process Context
  - Labs
- Transferring Between User and Kernel Space
  - Transferring Between Spaces
  - put(get)_user() and copy_to(from)_user()
  - Direct Transfer: Kernel I/O and Memory Mapping
  - Kernel I/O
  - Mapping User Pages
  - Memory Mapping
  - User-Space Functions for mmap()
  - Driver Entry Point for mmap()
  - Accessing Files from the Kernel
  - Labs
- Interrupts and Exceptions

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- What are Interrupts and Exceptions?
- Exceptions
- Asynchronous Interrupts
- MSI
- Enabling/Disabling Interrupts
- What You Cannot Do at Interrupt Time
- IRQ Data Structures
- Installing an Interrupt Handler
- Labs

- Timing Measurements
  - Kinds of Timing Measurements
  - Jiffies
  - Getting the Current Time
  - Clock Sources
  - Real Time Clock
  - Programmable Interval Timer
  - Time Stamp Counter
  - HPET
  - Going Tickless
  - Labs
- Kernel Timers
  - Inserting Delays
  - What are Kernel Timers?
  - Low Resolution Timer Functions
  - Low Resolution Timer Implementation
  - High Resolution Timers
  - Using High Resolution Timers
  - Labs
- ioctls
  - What are ioctls?
  - Driver Entry point for ioctls
  - Defining ioctls
  - Labs
- Unified Device Model and sysfs
  - Unified Device Model
  - Basic Structures

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- Real Devices
- sysfs
- kset and kobject examples
- Labs

- Firmware
  - What is Firmware?
  - Loading Firmware
  - Labs
- Sleeping and Wait Queues
  - What are Wait Queues?
  - Going to Sleep and Waking Up
  - Going to Sleep Details
  - Exclusive Sleeping
  - Waking Up Details
  - Polling
  - Labs
- Interrupt Handling: Deferrable Functions and User Drivers
  - Top and Bottom Halves
  - Softirqs
  - Tasklets
  - Work Queues
  - New Work Queue API
  - Creating Kernel Threads
  - Threaded Interrupt Handlers
  - Interrupt Handling in User-Space
  - Labs
- Hardware I/O
  - Buses and Ports
  - Memory Barriers
  - Registering I/O Ports
  - Reading and Writing Data from I/O Registers
  - Allocating and Mapping I/O Memory
  - Accessing I/O Memory
  - Access by User – ioperm(), iopl(), /dev/port
  - Labs
- PCI

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- What is PCI?
- PCI Device Drivers
- Locating PCI Devices
- Accessing Configuration Space
- Accessing I/O and Memory Spaces
- PCI Express
- Labs

- Platform Drivers**
  - What are Platform Drivers?
  - Main Data Structures
  - Registering Platform Devices
  - An Example
  - Hardcoded Platform Data
  - The New Way: Device Trees
  - Labs
- Direct Memory Access (DMA)
  - What is DMA?
  - DMA Directly to User
  - DMA and Interrupts
  - DMA Memory Constraints
  - DMA Masks
  - DMA API
  - DMA Pools
  - Scatter/Gather Mappings
  - Labs
- Network Drivers I: Basics
  - Network Layers and Data Encapsulation
  - Datalink Layer
  - Network Device Drivers
  - Loading/Unloading
  - Opening and Closing
  - Labs
- Network Drivers II: Data Structures
  - net_device Structure
  - net_device_ops Structure
  - sk_buff Structure

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- Socket Buffer Functions
- netdev_printk() and Associates
- Labs

- Network Drivers III: Transmission and Reception
  - Transmitting Data and Timeouts
  - Receiving Data
  - Statistics
  - Labs
- Network Drivers IV: Selected Topics
  - Multicasting **
  - Changes in Link State
  - ioctls
  - NAPI and Interrupt Mitigation
  - NAPI Details
  - TSO and TOE
  - MII and ethtool **
- USB Drivers
  - What is USB?
  - USB Topology
  - Terminology
  - Endpoints
  - Descriptors
  - USB Device Classes
  - USB Support in Linux
  - Registering USB Device Drivers
  - Moving Data
  - Example of a USB Driver
  - Labs
- Power Management
  - Power Management
  - ACPI and APM
  - System Power States
  - Callback Functions
  - Labs
- Block Drivers
  - What are Block Drivers?

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- Buffering
- Registering a Block Driver
- gendisk Structure
- Request Handling
- Labs

- Closing and Evaluation Survey
  - Evaluation Survey

** These sections may be considered in part or in whole as optional. They contain either background reference material, specialized topics, or advanced subjects. The instructor may choose to cover or not cover them depending on classroom experience and time constraints.

REQUIREMENTS:

Knowledge of basic kernel interfaces and methods such as how to write, compile, load and unload modules, use synchronization primitives, and the basics of memory allocation and management, such as is provided by LFD420 Linux Kernel Internals and Development. Pre-class preparation material will be provided before class.

Difficulty level



CERTIFICATE:

The participants will obtain certificates signed by The Linux Foundation.

TRAINER:

Certified The Linux Foundation Trainer.

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