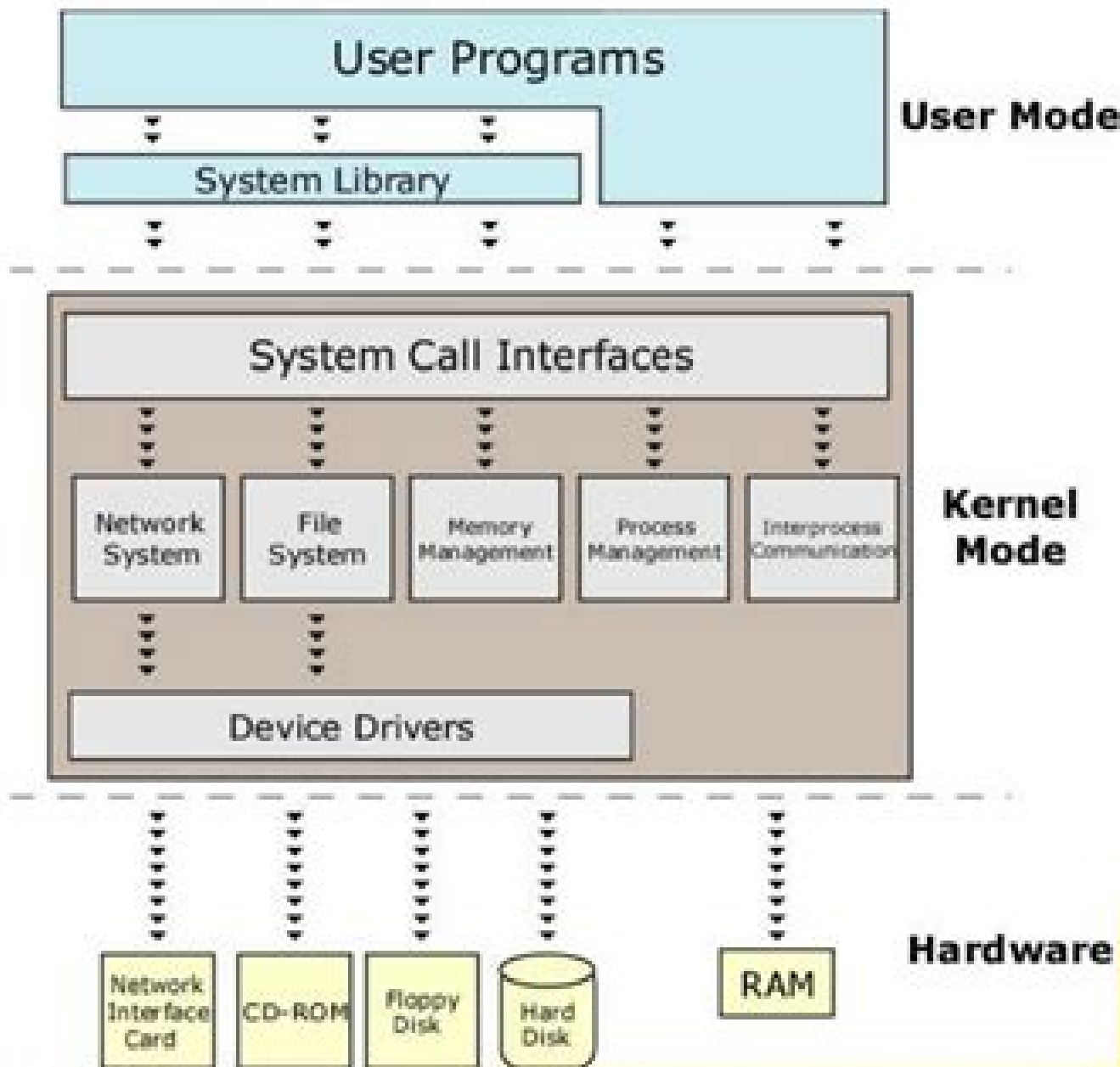


# Linux Kernel Architecture



# Linux Kernel Internals

**Haris Kundan Prasad**



## Linux Kernel Internals:

**Linux Kernel Programming** Kaiwan N Billimoria, 2021-03-19 Learn how to write high quality kernel module code solve common Linux kernel programming issues and understand the fundamentals of Linux kernel internals Key Features Discover how to write kernel code using the Loadable Kernel Module framework Explore industry grade techniques to perform efficient memory allocation and data synchronization within the kernel Understand the essentials of key internals topics such as kernel architecture memory management CPU scheduling and kernel synchronization Book Description Linux Kernel Programming is a comprehensive introduction for those new to Linux kernel and module development This easy to follow guide will have you up and running with writing kernel code in next to no time This book uses the latest 5.4 Long Term Support LTS Linux kernel which will be maintained from November 2019 through to December 2025 By working with the 5.4 LTS kernel throughout the book you can be confident that your knowledge will continue to be valid for years to come You'll start the journey by learning how to build the kernel from the source Next you'll write your first kernel module using the powerful Loadable Kernel Module LKM framework The following chapters will cover key kernel internals topics including Linux kernel architecture memory management and CPU scheduling During the course of this book you'll delve into the fairly complex topic of concurrency within the kernel understand the issues it can cause and learn how they can be addressed with various locking technologies mutexes spinlocks atomic and refcount operators You'll also benefit from more advanced material on cache effects a primer on lock free techniques within the kernel deadlock avoidance with lockdep and kernel lock debugging techniques By the end of this kernel book you'll have a detailed understanding of the fundamentals of writing Linux kernel module code for real world projects and products What you will learn Write high quality modular kernel code LKM framework for 5.x kernels Configure and build a kernel from source Explore the Linux kernel architecture Get to grips with key internals regarding memory management within the kernel Understand and work with various dynamic kernel memory alloc/dealloc APIs Discover key internals aspects regarding CPU scheduling within the kernel Gain an understanding of kernel concurrency issues Find out how to work with key kernel synchronization primitives Who this book is for This book is for Linux programmers beginning to find their way with Linux kernel development If you're a Linux kernel and driver developer looking to overcome frequent and common kernel development issues or understand kernel internals you'll find plenty of useful information You'll need a solid foundation of Linux CLI and C programming before you can jump in

**Linux Kernel Internals**, 1998 [Linux Kernel Internals](#) Michael Beck, 1998 Aimed at programmers this book shows how the Linux operating system actually works so that they can start to program the Linux kernel The CD ROM contains the Slackware distribution 3.1 together with its complete source code and much more

**Linux Kernel Programming** Kaiwan N. Billimoria, 2024-02-29 Gain a solid practical understanding and sufficient theoretical insight into Linux kernel internals while learning to write high quality kernel module code and understanding the complexities of kernel synchronization

Purchase of the print or Kindle book includes a free eBook in PDF format

**Key Features** Discover how to write Linux kernel and module code for real world products on the 6.1 LTS kernel Implement industry grade techniques in real world scenarios for fast efficient memory allocation and data synchronization Understand and exploit kernel architecture CPU scheduling and kernel synchronization techniques

**Book Description** The 2nd Edition of Linux Kernel Programming is an updated comprehensive guide for those new to Linux kernel development Built around the latest 6.1 Long Term Support LTS Linux kernel which is maintained until December 2026 this edition explores its key features and enhancements Additionally with the Civil Infrastructure Project extending support for the 6.1 Super LTS SLTS kernel until August 2033 this book will remain relevant for years to come You'll begin this exciting journey by learning how to build the kernel from source Step by step you will then learn how to write your first kernel module by leveraging the kernel's powerful Loadable Kernel Module LKM framework With this foundation you will delve into key kernel internals topics including Linux kernel architecture memory management and CPU task scheduling You'll finish with understanding the deep issues of concurrency and gain insight into how they can be addressed with various synchronization locking technologies for example mutexes spinlocks atomic refcount operators rw spinlocks and even lock free technologies such as per CPU and RCU By the end of this book you'll build a strong understanding of the fundamentals to writing the Linux kernel and kernel module code that can straight away be used in real world projects and products What you will learn

- Configure and build the 6.1 LTS kernel from source
- Write high quality modular kernel code LKM framework for 6.x kernels
- Explore modern Linux kernel architecture
- Get to grips with key internals details regarding memory management within the kernel
- Understand and work with various dynamic kernel memory alloc/dealloc APIs
- Discover key internals aspects regarding CPU scheduling within the kernel including cgroups v2
- Gain a deeper understanding of kernel concurrency issues
- Learn how to work with key kernel synchronization primitives

**Who this book is for** This book is for beginner Linux programmers and developers looking to get started with the Linux kernel providing a knowledge base to understand required kernel internal topics and overcome frequent and common development issues A basic understanding of Linux CLI and C programming is assumed

**Linux Internals Simplified** Haris Kundan Prasad, 2020-05-02 Linux internals simplified is a book which discusses the basics of Linux kernel internals in a code driven approach It picks the major subsystems of the kernel which are important and tries to simplify its internal working and data structures As such this book is aimed at engineers who wish to start learning about the Linux kernel This book starts with the basic steps to acquire the Linux kernel code It then shows ways of customizing the build options and lastly kernel compilation Next it looks at a number of hacking tools which will help one to debug and trace in a live Linux system Practical examples of ftrace kprobes and crash tool are discussed These tools are useful in trying to understand the way the Linux system works Chapter 3 discusses the details of a running process in a Linux system It touches topics such as address spaces of a running process user and kernel spaces system calls Linux process descriptor Linux process creation and so on This chapter builds a

foundation of a program in execution in the Linux system Once the reader knows about the running processes chapter 4 discusses about the Linux process scheduling subsystem This chapter discusses different data structures and code paths of the Linux scheduler which controls the scheduling of processes in the Linux system Chapter 5 discusses Interrupts which play a significant role in the Linux operating system The chapter discusses edge and level triggered interrupts interrupt handlers and their registration shared interrupt handlers and so on It also shows the ftrace of the `do_irq` function Chapter 6 discusses the signal subsystem It starts with a little introduction of the design of the signal subsystem It then traces the code execution of delivering and handling of signals in the Linux kernel The chapter then discusses signal overloading and how it is performed while exploring the kernel code which handles this Chapter 7 covers Linux synchronization primitives and why they are needed It shows the detailed implementation of primitives like atomic variables spinlocks semaphores and mutexes in the Linux kernel Chapter 8 discusses various ways of Linux kernel memory allocation It discusses Buddy allocator Resource map allocator and Slab allocator It discusses various APIs used for these allocators `alloc_page` `s_kmem_cache_alloc` `kmalloc` etc It also discusses how user space `malloc` results in memory allocation in the Linux kernel Chapter 9 discusses the Linux dynamic modules Linux character driver framework internal functions which are used while creating a character driver UDEV events and IOCTL interface It also discusses Linux device model It discusses example of bus device and `device_driver` components It illustrates device model when used in PCI BUS Chapter 10 covers the subsystem related to block IOs It starts with an introduction of filesystem and its purpose It then traces the path an IO takes right from the write system call to the moment it gets written to the disk The chapter covers basic data structures and design elements while going down the IO stack

Understanding Linux Network Internals Christian Benvenuti, 2005-12-29 If you've ever wondered how Linux carries out the complicated tasks assigned to it by the IP protocols or if you just want to learn about modern networking through real life examples Understanding Linux Network Internals is for you Like the popular O'Reilly book Understanding the Linux Kernel this book clearly explains the underlying concepts and teaches you how to follow the actual C code that implements it Although some background in the TCP/IP protocols is helpful you can learn a great deal from this text about the protocols themselves and their uses And if you already have a base knowledge of C you can use the book's code walkthroughs to figure out exactly what this sophisticated part of the Linux kernel is doing Part of the difficulty in understanding networks and implementing them is that the tasks are broken up and performed at many different times by different pieces of code One of the strengths of this book is to integrate the pieces and reveal the relationships between far flung functions and data structures Understanding Linux Network Internals is both a big picture discussion and a no nonsense guide to the details of Linux networking Topics include Key problems with networking Network interface card NIC device drivers System initialization Layer 2 link layer tasks and implementation Layer 3 IPv4 tasks and implementation Neighbor infrastructure and protocols ARP Bridging Routing ICMP Author Christian Benvenuti an operating system designer specializing in networking

explains much more than how Linux code works He shows the purposes of major networking features and the trade offs involved in choosing one solution over another A large number of flowcharts and other diagrams enhance the book s understandability *LF320 Linux Kernel Internals and Debugging* Linux Foundation,2010-04-29 Linux Kernel Internals and Debugging is designed to provide experienced programmers with a solid understanding of the Linux kernel Upon mastering this material you will have a basic understanding of the Linux architecture kernel algorithms hardware and memory management modularization techniques and debugging *Linux Kernel Debugging* Kaiwan N. Billimoria,2022-08-05 Effectively debug kernel modules device drivers and the kernel itself by gaining a solid understanding of powerful open source tools and advanced kernel debugging techniques Key Features Fully understand how to use a variety of kernel and module debugging tools and techniques using examples Learn to expertly interpret a kernel Oops and identify underlying defect s Use easy to look up tables and clear explanations of kernel level defects to make this complex topic easy Book DescriptionThe Linux kernel is at the very core of arguably the world s best production quality OS Debugging it though can be a complex endeavor Linux Kernel Debugging is a comprehensive guide to learning all about advanced kernel debugging This book covers many areas in depth such as instrumentation based debugging techniques printk and the dynamic debug framework and shows you how to use Kprobes Memory related bugs tend to be a nightmare two chapters are packed with tools and techniques devoted to debugging them When the kernel gifts you an Oops how exactly do you interpret it to be able to debug the underlying issue We ve got you covered Concurrency tends to be an inherently complex topic so a chapter on lock debugging will help you to learn precisely what data races are including using KCSAN to detect them Some thorny issues both debug and performance wise require detailed kernel level tracing you ll learn to wield the impressive power of Ftrace and its frontends You ll also discover how to handle kernel lockups hangs and the dreaded kernel panic as well as leverage the venerable GDB tool within the kernel KGDB along with much more By the end of this book you will have at your disposal a wide range of powerful kernel debugging tools and techniques along with a keen sense of when to use which What you will learn Explore instrumentation based printk along with the powerful dynamic debug framework Use static and dynamic Kprobes to trap into kernel module functions Catch kernel memory defects with KASAN UBSAN SLUB debug and kmemleak Interpret an Oops in depth and precisely identify it s source location Understand data races and use KCSAN to catch evasive concurrency defects Leverage Ftrace and trace cmd to trace the kernel flow in great detail Write a custom kernel panic handler and detect kernel lockups and hangs Use KGDB to single step and debug kernel module source code Who this book is for This book is for Linux kernel developers module driver authors and testers interested in debugging and enhancing their Linux systems at the level of the kernel System administrators who want to understand and debug the internal infrastructure of their Linux kernels will also find this book useful A good grasp on C programming and the Linux command line is necessary Some experience with kernel module development will help you follow along [Linux Internals](#)

Moshe Bar,2000-01-01 Furnishing in depth coverage of Linux source code internals this high level handbook explains how the Linux system operating system works and how to use it with various programming applications discussing the various Linux versions performance and tuning issues kernel programming troubleshooting details and other important topics  
Original Intermediate      [Professional Linux Kernel Architecture](#) Wolfgang Maueer,2010-03-11 Find an introduction to the architecture concepts and algorithms of the Linux kernel in Professional Linux Kernel Architecture a guide to the kernel sources and large number of connections among subsystems Find an introduction to the relevant structures and functions exported by the kernel to userland understand the theoretical and conceptual aspects of the Linux kernel and Unix derivatives and gain a deeper understanding of the kernel Learn how to reduce the vast amount of information contained in the kernel sources and obtain the skills necessary to understand the kernel sources      [Hands-On System Programming with Linux](#) Kaiwan N Billimoria,2018-10-31 Get up and running with system programming concepts in Linux Key FeaturesAcquire insight on Linux system architecture and its programming interfacesGet to grips with core concepts such as process management signalling and pthreadsPacked with industry best practices and dozens of code examplesBook Description The Linux OS and its embedded and server applications are critical components of today s software infrastructure in a decentralized networked universe The industry s demand for proficient Linux developers is only rising with time Hands On System Programming with Linux gives you a solid theoretical base and practical industry relevant descriptions and covers the Linux system programming domain It delves into the art and science of Linux application programming system architecture process memory and management signaling timers pthreads and file IO This book goes beyond the use API X to do Y approach it explains the concepts and theories required to understand programming interfaces and design decisions the tradeoffs made by experienced developers when using them and the rationale behind them Troubleshooting tips and techniques are included in the concluding chapter By the end of this book you will have gained essential conceptual design knowledge and hands on experience working with Linux system programming interfaces What you will learnExplore the theoretical underpinnings of Linux system architectureUnderstand why modern OSes use virtual memory and dynamic memory APIsGet to grips with dynamic memory issues and effectively debug themLearn key concepts and powerful system APIs related to process managementEffectively perform file IO and use signaling and timersDeeply understand multithreading concepts pthreads APIs synchronization and schedulingWho this book is for Hands On System Programming with Linux is for Linux system engineers programmers or anyone who wants to go beyond using an API set to understanding the theoretical underpinnings and concepts behind powerful Linux system programming APIs To get the most out of this book you should be familiar with Linux at the user level logging in using shell via the command line interface the ability to use tools such as find grep and sort Working knowledge of the C programming language is required No prior experience with Linux systems programming is assumed      **Linux Kernel Programming Part 2 - Char Device Drivers and Kernel**

**Synchronization** Kaiwan N Billimoria, 2021-03-19 Discover how to write high quality character driver code interface with userspace work with chip memory and gain an in depth understanding of working with hardware interrupts and kernel synchronization Key Features Delve into hardware interrupt handling threaded IRQs tasklets softirqs and understand which to use when Explore powerful techniques to perform user kernel interfacing peripheral I O and use kernel mechanisms Work with key kernel synchronization primitives to solve kernel concurrency issues Book Description Linux Kernel Programming Part 2 Char Device Drivers and Kernel Synchronization is an ideal companion guide to the Linux Kernel Programming book This book provides a comprehensive introduction for those new to Linux device driver development and will have you up and running with writing misc class character device driver code on the 5.4 LTS Linux kernel in next to no time You'll begin by learning how to write a simple and complete misc class character driver before interfacing your driver with user mode processes via procfs sysfs debugfs netlink sockets and ioctl You'll then find out how to work with hardware I O memory The book covers working with hardware interrupts in depth and helps you understand interrupt request IRQ allocation threaded IRQ handlers tasklets and softirqs You'll also explore the practical usage of useful kernel mechanisms setting up delays timers kernel threads and workqueues Finally you'll discover how to deal with the complexity of kernel synchronization with locking technologies mutexes spinlocks and atomic refcount operators including more advanced topics such as cache effects a primer on lock free techniques deadlock avoidance with lockdep and kernel lock debugging techniques By the end of this Linux kernel book you'll have learned the fundamentals of writing Linux character device driver code for real world projects and products What you will learn Get to grips with the basics of the modern Linux Device Model LDM Write a simple yet complete misc class character device driver Perform user kernel interfacing using popular methods Understand and handle hardware interrupts confidently Perform I O on peripheral hardware chip memory Explore kernel APIs to work with delays timers kthreads and workqueues Understand kernel concurrency issues Work with key kernel synchronization primitives and discover how to detect and avoid deadlock Who this book is for An understanding of the topics covered in the Linux Kernel Programming book is highly recommended to make the most of this book This book is for Linux programmers beginning to find their way with device driver development Linux device driver developers looking to overcome frequent and common kernel driver development issues as well as perform common driver tasks such as user kernel interfaces performing peripheral I O handling hardware interrupts and dealing with concurrency will benefit from this book A basic understanding of Linux kernel internals and common APIs kernel module development and C programming is required **Linux Kernel Programming** Michael Beck, 2002 CD ROM contains Linux kernel version 2.4.4 plus sources from other programs and documents from the Linux Documentation Project **Linux Kernel Development** John Smith, 2024-04-26 Unlock the secrets of the Linux kernel with Linux Kernel Development A Deep Dive into Operating System Internals a comprehensive guide tailored for professionals developers and students alike who are eager to enhance their understanding of one of the



most robust and widely used operating systems in the tech world This book meticulously demystifies the complex structure and functioning of the Linux kernel covering core concepts such as process management memory management and device drivers among others Linux Kernel Development not only explores theoretical underpinnings but also provides practical insights and step by step guidance on real world applications Each chapter is dedicated to a specific aspect of the kernel from its architecture to its security features offering readers a systematic approach to mastering Linux systems Whether you re looking to refine your technical skills contribute to the Linux community or implement advanced kernel operations in your projects this book is an indispensable resource Dive into kernel processes understand how data is managed and discover how to optimize the kernel for various environments with this authoritative text Embrace the opportunity to gain a deeper understanding of the Linux kernel and advance your capabilities in system design development and administration Linux Kernel Development is your gateway to becoming a proficient and knowledgeable contributor to the Linux ecosystem

Linux Kernel Programming ,2002      Linux: The Ultimate Guide for Beginners and Pros Pasquale De Marco,2025-05-04 Embark on an educational journey into the world of Linux with Linux The Ultimate Guide for Beginners and Pros the ultimate guide for both beginners and experienced users alike This comprehensive resource delves into the fundamentals of Linux empowering readers to harness its capabilities effectively Whether you re a seasoned Linux user seeking to expand your knowledge or a novice eager to explore the world of open source software Linux The Ultimate Guide for Beginners and Pros is an invaluable resource It covers a wide range of topics from basic concepts to advanced system administration ensuring that readers gain a comprehensive understanding of Linux Linux has proven its mettle in diverse applications from powering web servers and cloud computing platforms to serving as the backbone of embedded systems and supercomputers Linux The Ultimate Guide for Beginners and Pros explores these use cases providing insights into the versatility and adaptability of Linux Furthermore the book delves into emerging Linux technologies such as containers and virtualization which are transforming the way applications are developed and deployed Readers will gain a glimpse into the future of Linux and its potential to shape the technological landscape in the years to come With Linux The Ultimate Guide for Beginners and Pros as your guide you ll master the intricacies of Linux and become proficient in its usage Its approachable style and clear explanations make it an indispensable companion for anyone looking to unlock the limitless possibilities of this powerful operating system Join the millions of users who rely on Linux for their computing needs Get your copy of Linux The Ultimate Guide for Beginners and Pros today and empower yourself with the knowledge and skills to navigate the ever evolving world of technology If you like this book write a review on google books      Linux System Programming Techniques Jack-Benny Persson,2021-05-07 Find solutions to all your problems related to Linux system programming using practical recipes for developing your own system programs Key FeaturesDevelop a deeper understanding of how Linux system programming worksGain hands on experience of working with different Linux projects with the help of practical examplesLearn how to

develop your own programs for Linux

**Book Description** Linux is the world's most popular open source operating system. OS Linux System Programming Techniques will enable you to extend the Linux OS with your own system programs and communicate with other programs on the system. The book begins by exploring the Linux filesystem, its basic commands, built-in manual pages, the GNU compiler collection, GCC, and Linux system calls. You'll then discover how to handle errors in your programs and will learn to catch errors and print relevant information about them. The book takes you through multiple recipes on how to read and write files on the system using both streams and file descriptors. As you advance, you'll delve into forking, creating zombie processes, and daemons, along with recipes on how to handle daemons using `systemd`. After this, you'll find out how to create shared libraries and start exploring different types of interprocess communication (IPC). In the later chapters, recipes on how to write programs using POSIX threads and how to debug your programs using the GNU debugger GDB and Valgrind will also be covered. By the end of this Linux book, you will be able to develop your own system programs for Linux, including daemons, tools, clients, and filters. What you will learn:

- Discover how to write programs for the Linux system using a wide variety of system calls.
- Delve into the working of POSIX functions.
- Understand and use key concepts such as signals, pipes, IPC, and process management.
- Find out how to integrate programs with a Linux system.
- Explore advanced topics such as filesystem operations, creating shared libraries, and debugging your programs.
- Gain an overall understanding of how to debug your programs using Valgrind.

**Who this book is for** This book is for anyone who wants to develop system programs for Linux and gain a deeper understanding of the Linux system. The book is beneficial for anyone who is facing issues related to a particular part of Linux system programming and is looking for specific recipes or solutions.

**Building Embedded Linux Systems** Karim Yaghmour, 2003-04-22 Linux is being adopted by an increasing number of embedded systems developers who have been won over by its sophisticated scheduling and networking, its cost-free license, its open development model, and the support offered by rich and powerful programming tools. While there is a great deal of hype surrounding the use of Linux in embedded systems, there is not a lot of practical information. *Building Embedded Linux Systems* is the first in-depth, hard-core guide to putting together an embedded system based on the Linux kernel. This indispensable book features arcane and previously undocumented procedures for:

- Building your own GNU development toolchain.
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- Creating a complete target root filesystem.
- Setting up, manipulating, and using solid-state storage devices.
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- Cross-compiling a slew of utilities and packages.
- Debugging your embedded system using a plethora of tools and techniques.

Details are provided for various target architectures and hardware configurations, including a thorough review of Linux's support for embedded hardware. All explanations rely on the use of open source and free software packages. By presenting how to build the operating system components from pristine sources and how to find more documentation or help, this book greatly simplifies the task of keeping complete control over one's embedded operating system, whether it be for

technical or sound financial reasons Author Karim Yaghmour a well known designer and speaker who is responsible for the Linux Trace Toolkit starts by discussing the strengths and weaknesses of Linux as an embedded operating system Licensing issues are included followed by a discussion of the basics of building embedded Linux systems The configuration setup and use of over forty different open source and free software packages commonly used in embedded Linux systems are also covered uClibc BusyBox U Boot OpenSSH tthttpd tftp strace and gdb are among the packages discussed **Embedded**

**Android** Karim Yaghmour,2013-03-15 Embedded Android is for Developers wanting to create embedded systems based on Android and for those wanting to port Android to new hardware or creating a custom development environment Hackers and moders will also find this an indispensable guide to how Android works Shellcoder's Programming Uncovered (Uncovered series) Kris Kaspersky,2005 How hackers viruses and worms attack computers from the Internet and exploit security holes in software is explained in this outline of antivirus software patches and firewalls that try in vain to withstand the storm of attacks Some software s effectiveness exists only in the imaginations of its developers because they prove unable to prevent the propagation of worms but this guide examines where security holes come from how to discover them how to protect systems both Windows and Unix and how to do away with security holes altogether Unpublished advanced exploits and techniques in both C and Assembly languages are

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