嵌入式系统开发(影印版)

Making Embedded Systems

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Elecia White 著

嵌入式系统开发(影印版)

是否有兴趣开发嵌入式系统？这些系统无法容忍低下的效率，它们需要遵循严格的方式进行编程。这本易于阅读的指南通过经典的软件设计模式和嵌入式编程的全新模式来帮助你培养许多良好的开发习惯。你会学习到如何为处理器而不是操作系统来搭建系统架构，并且了解到处理硬件问题和制造工艺所需的特殊技术。

这本书的作者创建过各种各样的嵌入式系统，从城市监控和DNA扫描仪到儿童玩具。本书适合于中等和有经验的编程人员，无论你使用的是什么平台。

- 优化你的系统以减少损耗并增强性能
- 开发一套能够让你的软件在资源有限的环境中稳定运行的架构
- 探讨传感器、电机和其他I/O设备
- 少花钱多办事：减少内存使用、编码空间、处理器周期和电量损耗
- 学习如何在处理器中直接更新嵌入式代码
- 了解如何在小型处理器上实现复杂数学计算
- 当你寻求一份嵌入式系统工作时明白面试人员在说些什么

“《嵌入式系统开发》是一本适合希望进入有趣（也有利可图）的嵌入式领域的C程序员的书籍。这本书写得非常好——寓教于乐——并且讲解明晰。”

——Jack Ganssle
作家同时也是
嵌入式系统专家

Elecia White是Logical Elegance，一家在圣何塞的嵌入式系统咨询公司的创办人。她喜欢制作有趣的玩意，包括医学设备、惯性测量装置、教育玩具和一套枪声定位系统。

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Preface

I love embedded systems. The first time a motor turned because I told it to, I was hooked. I quickly moved away from pure software and into a field where I can touch the world. Just as I was leaving software, the seminal work was done on design patterns.* My team went through the book, discussing the patterns and where we'd consider using them. As I got more into embedded systems, I found compilers that couldn't handle C++ inheritance, processors with absurdly small amounts of memory in which to implement the patterns, and a whole new set of problems where design patterns didn't seem applicable. But I never forgot the idea that there are patterns to the way we do engineering. By learning to recognize the patterns, we can use the robust solutions over and over. So much of this book looks at standard patterns and offers some new ones for embedded system development. I've also filled in a number of chapters with other useful information not found in most books.

About This Book

After seeing embedded systems in medical devices, race cars, airplanes, children's toys, and gunshot location systems, I've found a lot of commonalities. There are a lot of things I wish I knew then on how to go about designing and implementing software for an embedded system. This book contains some of what I've learned. It is a book about good software design in resource-constrained environments.

It is also a book about understanding what interviewers look for when you apply for an embedded systems job. Each section ends with an interview question. These are generally not language specific; instead, they attempt to divine how you think. Good interview questions don't have a single correct answer. Instead of trying to document all the paths, the notes after each question provide hints about what an interviewer might look for in your response. You'll have to get the job (and the answers) on your own merits.

* Gamma, Erich, Richard Helm, Ralph Johnson, and John Vlissides, 1995. *Design Patterns: Elements of Reusable Object-Oriented Software*. Boston: Addison-Wesley.

One note, though: my embedded systems don't have operating systems. The software runs on the bare metal. When the software says "turn that light on," it says it to the processor without an intermediary. This isn't a book about an embedded operating system (OS). But the concepts translate to processors running OSs, so if you stick around, you may learn about the undersides of OSs too. Working without one helps you really appreciate what an OS does.

This book describes the archetypes and principles that are commonly used in creating embedded system software. I don't cover any particular platform, processor, compiler, or language, because if you get a good foundation from this book, specifics can come later.

About the Author

In the field of embedded systems, I have worked on DNA scanners, inertial measurement units for airplanes and race cars, toys for preschoolers, a gunshot location system for catching criminals, and assorted medical and consumer devices.

I have specialized in signal processing, hardware integration, complex system design, and performance. Having been through FAA and FDA certification processes, I understand the importance of producing high-quality designs and how they lead to high-quality implementations.

I've spent several years in management roles, but I enjoy hands-on engineering and the thrill of delivering excellent products. I'm happy to say that leaving management has not decreased my opportunities to provide leadership and mentoring.

Acknowledgments

This book didn't happen in a vacuum. It started with a colleague who said, "Hey, do you know a book I can give to one of my junior engineers?" From that planted seed came months of writing; I learned to really appreciate understanding (and encouraging) friends. Then there were the engineers who gave their time to look at the technical material (any remaining issues are my fault, not theirs, of course). Finally, O'Reilly provided tremendous support through the whole process.

Thanking each person as they properly deserve would take pages and pages, so I will just go through them all in one breath, in no particular order: Phillip King, Ken Brown, Jerry Ryle, Matthew Hughes, Eric Angell, Scott Fitzgerald, John Catsoulis, Robert P. J. Day, Rebecca Demarest, and Jen Costillo. These folks made a difference in the flavor of this book. There are additional thank-yous spread throughout the book, where I got help from a particular person on a particular area, so you may see these names again (or a few different ones).

Two people are left out of that list. Andy Oram is an excellent editor at O'Reilly, and I was lucky to get him. He's made a big difference to this book and to my writing.

Finally, authors always give gushing thanks to their spouses; it is a cliché. However, having written a book, I see why. Christopher White, my favorite drummer, physicist, and embedded systems engineer, thank you most of all. For everything.

Organization of This Book

I read nonfiction for amusement. I read a lot more fiction than nonfiction, but still, I like any good book. I wrote this book to be read almost as a story, from cover to cover. The information is technical (extremely so in spots), but the presentation is casual. You don't need to program along with it to get the material (though trying out the examples and applying the recommendations to your code will give you a deeper understanding).

This isn't intended to be a technical manual where you can skip into the middle and read only what you want. I mean, you can do that, but you'll miss a lot of information with the search-and-destroy method. You'll also miss the jokes, which is what I really would feel bad about. I hope that you go through the book in order. Then, when you are hip-deep in alligators and need to implement a function fast, pick up the book, flip to the right chapter, and, like a wizard, whip up a command table or fixed point implementation of variance.

Or you can skip around, reading about solutions to your crisis of the week. I understand. Sometimes you just have to solve the problem. If that is the case, I hope you find the chapter interesting enough to come back when you are done fighting that fire.

The order of chapters is:

Chapter 1, Introduction
: What is an embedded system? How is development different from traditional software?

Chapter 2, Creating a System Architecture
: How to create (and document) a system architecture.

Chapter 3, Getting Your Hands on the Hardware
: Hardware/software integration during board bring-up can be scary, but there are some ways to make it smoother.

Chapter 4, Outputs, Inputs, and Timers
: The embedded systems version of "Hello World" is making an LED blink. It can be more complex than you might expect.

Chapter 5, Managing the Flow of Activity
: This chapter describes how to set up your system, where to use interrupts (and how not to), and how to make a state machine.

Chapter 6, Communicating with Peripherals
: Different serial communication forms rule embedded systems (UART, SSP, SPI, I^2C, USB, etc.). Networking, bit-bang, and parallel buses are not to be discounted.

Chapter 7, Updating Code
: When you need to replace the program running in your processor, you have a few options ranging from internal updaters to building your own solution.

Chapter 8, Doing More with Less
: This covers methods for reducing consumption of RAM, code space, and processor cycles.

Chapter 9, Math
: Most embedded systems need to do some form of analysis. Understanding how mathematical operations and floating points work (and don't work) will make your system faster.

Chapter 10, Reducing Power Consumption
: From reducing processor cycles to system architecture suggestions, this chapter will help you if your system runs on batteries.

The information is presented in the order that I want my engineers to start thinking about these things. It may seem odd that architecture is first, considering that most people don't get to it until later in their careers. However, I want the people I work with to be thinking about how their code fits in the system long before I want them to worry about optimization.

Conventions Used in This Book

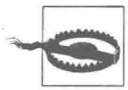
Typography

The following typographical conventions are used in this book:

Italic
: Indicates new terms, URLs, filenames, and file extensions.

`Constant width`
: Used for program listings, as well as within paragraphs to refer to program elements such as variable or function names, data types, and keywords.

This icon signifies a tip, suggestion, or general note.



This icon indicates a warning or caution.

Terminology

A *microcontroller* is a processor with onboard goodies like RAM, code space (usually flash), and various peripheral interfaces (e.g., I/O lines). Your code runs on a processor, or *central processing unit* (CPU). A *microprocessor* is a small processor, but the definition of "small" changes.

A DSP (*digital signal processor)* is a specialized form of microcontroller that focuses on signal processing, usually sampling analog signals and doing something interesting with the result. Usually a DSP is also a microcontroller, but it has special tweaks to make it perform math operations faster (in particular, multiply and add).

As I wrote this book, I wanted to use the correct terminology so you'd get used to it. However, with so many names for the piece of the system that is running your code, I didn't want to add confusion by changing the name. So, I stick with the term *processor* to represent whatever it is you're using to implement your system. Most of the material is applicable to whatever you actually have.

Using Code Examples

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