PREFACE

When I first taught computer organization to computer science majors here at East Tennessee State University, I was not sure where to begin. My training as an electrical engineer provided me with a background in DC and AC electrical theory, electronics, and circuit design. Was this where I needed to start? Do computer science majors really need to understand computers at the transistor level?

The textbook used by my predecessors assumed the reader had had some experience with electronics. The author went so far as to use screen captures from oscilloscopes and other test equipment to describe circuit properties. I soon found that this was a bad assumption to make when it came to students of computer science.

To provide a lifeline to my floundering students, I began writing supplementary notes and posting them to my web site. Over the years, the notes matured until eventually students stopped buying the course textbook. When the on-line notes were discovered by search engines, I began receiving messages from other instructors asking if they could link to my notes. The answer was obvious: of course!

The on-line notes provided a wonderful opportunity. Instead of requiring a textbook for my course, I could ask my students to purchase hardware or software to supplement the university's laboratory equipment. This could include anything from external hard drives to circuit components. By enhancing the hands-on portion of the course, I hope that I have improved each student's chance to learn and retain the material.[1]

In April of 2004, I became aware of recent advances in self-publishing with services such as Lulu.com. In an effort to reduce the costs paid by students who were printing the course notes from the web, I decided to compile my web notes into a book. For years, I had been receiving comments from students about dried up printer cartridges. I once found a student searching the recycled paper bin for scrap paper on which to print my notes. Even our campus technology group had begun to suggest I was one of the causes for the overuse of campus printers.

[1] Korwin, Anthony R., Jones, Ronald E., “Do Hands-On, Technology-Based Activities Enhance Learning by Reinforcing Cognitive Knowledge and Retention?” Journal of Technology Education, Vol. 1, No. 2, Spring 1990. Online. Internet. Available WWW: http://scholar.lib.vt.edu/ejournals/JTE/v1n2/pdf/jones.pdf

So here it is, a textbook open to any audience with a simple desire to learn about the digital concepts of a computer. I've tried to address topics such as analog to digital conversion, CRC's, and memory organization using practical terms and examples instead of the purely theoretical or technical approaches favored by engineers. Hopefully I've succeeded.

I do not pretend to believe that this book alone will provide the reader with the background necessary to begin designing and building contemporary computer circuits. I do, however, believe that reading it will give people the tools to become better developers of software and computer systems by understanding the tools for logic design and the organization of the computer's internals.

The design concepts used for hardware are just as applicable to software. In addition, an understanding of hardware can be applied to software design allowing for improved system performance. This book can be used as a springboard to topics such as advanced computer architecture, embedded system design, network design, compiler design, or microprocessor design. The possibilities are endless.

Organization of This Book

The material in this book is presented in three stages. The first stage, Chapters 1 through 7, discusses the mathematical foundation and design tools that address the digital nature of computers. The discussion begins in Chapters 1, 2, and 3 where the reader is introduced to the differences between the physical world and the digital world. These chapters show how the differences affect the way the computer represents and manipulates data. Chapter 4 introduces digital logic and logic gates followed by Chapters 5, 6, and 7 where the tools of design are introduced.

The second stage, Chapters 8 through 11, applies the fundamentals of the first stage to standard digital designs such as binary adders and counters, checksums and cyclic redundancy checks, network addressing, storage devices, and state machines.

The last stage, Chapters 12 through 17, presents the top-level view of the computer. It begins with the organization of addressable memory in Chapter 12. This is followed in Chapter 13 with a discussion of the memory hierarchy starting with the physical construction of hard drives and ending with the organization of cache memory and processor registers. Chapter 14 brings the reader through the concepts of serial

protocols ending with a description of the IEEE 802.3 Ethernet protocol. Chapter 15 presents the theories of computer architecture while Chapters 16 and 17 use the Intel 80x86 family as a means of example.

Each chapter concludes with a short section titled "What's Next?" describing where the next chapter will take the reader. This is followed by a set of questions that the reader may use to evaluate his or her understanding of the topic.

Acknowledgements

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I would also like to thank my computer organization students who tolerated being the test bed of this textbook. Many of them provided suggestions that strengthened the book, and I am grateful to them all.

Most of all, I would like to thank my wife, Karen, who has always encouraged and supported me in each of my endeavors. You provide the foundation of my success.

Lastly, even self-published books cannot be realized without some support. I would like to thank those who participate as contributors and moderators on the Lulu.com forums. In addition, I would like to thank Lulu.com directly for providing me with a quality outlet for my work.

Disclaimer

The information in this book is based on the personal knowledge collected by David Tarnoff through years of study in the field of electrical engineering and his work as an embedded system designer. While he believes this information is correct, he accepts no responsibility or liability whatsoever with regard to the application of any of the material presented in this book.

In addition, the design tools presented here are meant to act as a foundation to future learning. David Tarnoff offers no warranty or guarantee toward products used or developed with material from this book. He also denies any liability arising out of the application of any tool or product discussed in this book. If the reader chooses to use the

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