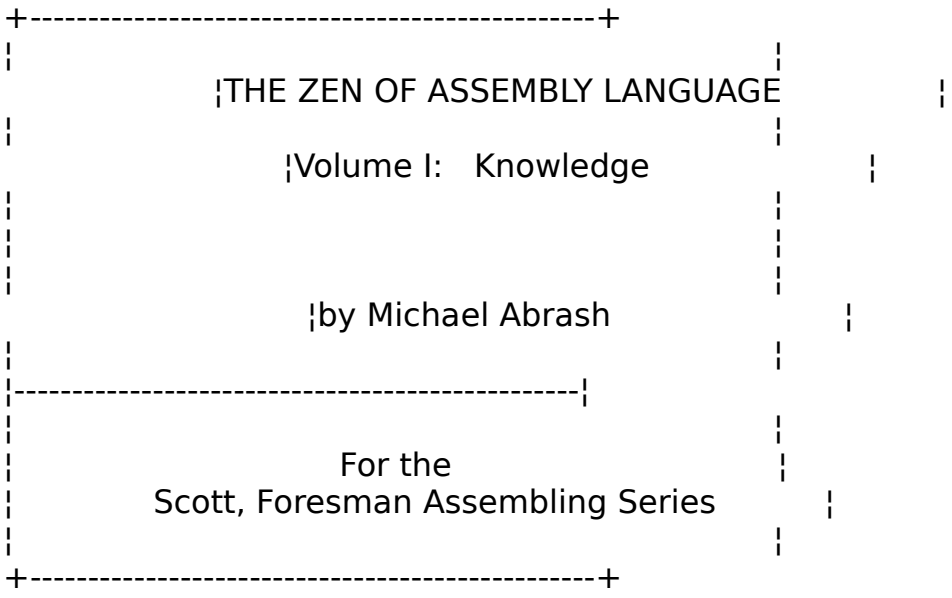
THE ZEN OF ASSEMBLY LANGUAGE
Volume I: Knowledge
by Michael Abrash
For the
Scott, Foresman Assembling Series

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For Shay and Emily

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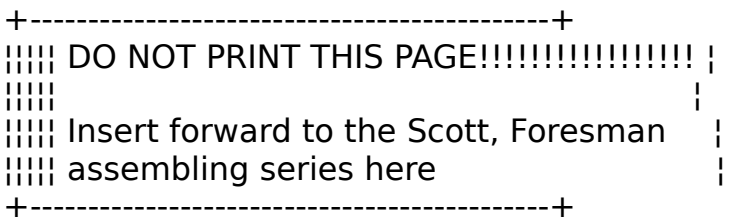
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¦¦¦¦¦   ¦
¦¦¦¦¦ Introduction: Pushing the Envelope ¦
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This is the book I wished for with all my heart seven years ago, when I started programming the IBM PC: the book that unlocks the secrets of writing superb assembly-language code. There was no such book then, so I had to learn the hard way, through experimentation and through trial and error. Over the years, I waited in vain for that book to appear; I looked everywhere without success for a book about advanced assembly- language programming, a book written specifically for assembly- language programmers who want to get better, rather than would-be assembly-language programmers. I'm sure many of you have waited for such a book as well. Well, wait no longer: this is that book.

The Zen of Assembly Language assumes that you're already familiar with assembly language. Not an expert, but at least acquainted with the registers and instructions of the 8088, and with the use of one of the popular PC assemblers. Your familiarity with assembly language will allow us to skip over the droning tutorials about the use of the assembler and the endless explanations of binary arithmetic that take up hundreds of pages in introductory books. We're going to jump into high-performance programming right from the start, and when we come up for air 16 chapters from now, your view of assembly language will be forever altered for the

better. Then we'll leap right back into Volume II, applying our newfound knowledge of assembly language to ever- more-sophisticated programming tasks.

In short, The Zen of Assembler is about nothing less than how to become the best assembly-language programmer you can be.

WHY ASSEMBLY LANGUAGE?

For years, people have been predicting--hoping for--the demise of assembly language, claiming that the world is ready to move on to less primitive approaches to programming...and for years, the best programs around have been written in assembly language. Why is this? Simply because assembly language is hard to work with, but--properly used--produces programs of unparalleled performance. Mediocre programmers have a terrible time working with assembly language; on the other hand, assembly language is, without fail, the language that PC gurus use when they need the best possible code.

Which brings us to you.

Do you want to be a guru? I'd imagine so, if you're reading this book. You've set yourself an ambitious and difficult goal, and your success is far from guaranteed. There's no sure-fire recipe for becoming a guru, any more than there's a recipe for becoming a chess grand master. There is, however, one way you can greatly improve your chances: become an expert assembly language programmer. Assembly language won't by itself make you a guru--but without it you'll never reach your full potential as a

programmer.

Why is assembly language so important in this age of optimizing compilers and program generators? Assembly language is fundamentally different from all other languages, as we'll see throughout The Zen of Assembly Language. Assembly language lets you use every last resource of the PC to push the performance envelope; only in assembly language can you press right up against the inherent limits of the PC.

If you aren't pushing the envelope, there's generally no reason to program in assembler. High-level languages are certainly easier to use, and nowadays most high-level languages let you get at the guts of the PC--display memory, DOS functions, interrupt vectors, and so on--without having to resort to assembler. If, in the other hand, you're striving for the sort of performance that will give your programs snappy interfaces and crackling response times, you'll find assembly language to be almost magical, for no other language even approaches assembler for sheer speed.

Of course, no one tests the limits of the PC with their first assembler program; that takes time and practice. While many PC programmers know something about assembler, few are experts. The typical programmer has typed in the assembler code from an article or two, read a book about assembler programming, and perhaps written a few assembler programs of his own--but doesn't yet feel that he has mastered the language. If you fall into this category, you've surely sensed the remarkable potential of assembler, but you're also keenly aware of how hard it is to write good assembler code and how much you have yet to learn. In

all likelihood, you're not sure how to sharpen your assembler skills and take that last giant step toward mastery of your PC.

This book is for you.

Welcome to the most exciting and esoteric aspect of the IBM PC. The Zen of Assembly Language will teach you how to create blindingly fast code for the IBM PC. More important still, it will teach you how to continue to develop your assembler programming skills on your own. The Zen of Assembly Language will show you a way to learn what you need to know as the need arises, and it is that way of learning that will serve you well for years to come. There are facts and code aplenty in this book and in the companion volume, but it is a way of thinking and learning that lies at the heart of The Zen of Assembly Language.

Don't take the title to mean that this is a mystical book in any way. In the context of assembly-language programming, Zen is a technique that brings intuition and non-obvious approaches to bear on difficult problems and puzzles. If you would rather think of high-performance assembler programming as something more mundane, such as right-brained thinking or plain old craftsmanship, go right ahead; good assembler programming is a highly individualized process.

The Zen of Assembly Language is specifically about assembly language for the IBM PC (and, by definition, compatible computers). In particular, the bulk of this volume will focus on the capabilities of the 8088 processor that lies at the heart of the PC. However, many of the findings and almost all of the techniques I'll discuss can also be applied to assembly-

language programming for the other members of Intel's 808X processor family, including the 80286 and 80386 processors, as we'll see toward the end of this volume. The Zen of Assembly Language doesn't much apply to computers built around other processors, such as the 68XXX family, the Z80, the 8080, or the 6502, since a great deal of the Zen of assembly language in the case of the IBM PC derives from the highly unusual architecture of the 808X family. (In fact, the processors in the 808X family lend themselves beautifully to assembly language, much more so than other currently-popular processors.)

While I will spend a chapter looking specifically at the 80286 found in the AT and PS/2 Models 50 and 60 and at the 80386 found in the PS/2 Model 80, I'll concentrate primarily on the 8088 processor found in the IBM PC and XT, for a number of reasons. First, there are at least 15,000,000 8088-based computers around, ensuring that good 8088 code isn't going to go out of style anytime soon. Second, the 8088 is far and away the slowest of the processors used in IBM-compatible computers, so no matter how carefully code is tailored to the subtleties of the 8088, it's still going to run much faster on an 80286 or 80386. Third, many of the concepts I'll present regarding the 8088 apply to the 80286 and 80386 as well, but to a different degree. Given that there are simply too many processors around to cover in detail (and the 80486 on the way), I'd rather pay close attention to the 8088, the processor for which top-quality code is most critical, and provide you with techniques that will allow you to learn on your own how best to program other processors.

We'll return to this topic in Chapter 15, when we will in fact discuss other 808X-family processors, but for now, take my word for it: when it comes to optimization, the 8088 is the processor of choice.

WHAT YOU'LL NEED

The tools you'll need to follow this book are simple: a text editor to create ASCII program files, the Microsoft Macro Assembler version 5.0 or a compatible assembler (Turbo Assembler is fine) to assemble programs, and the Microsoft Linker or a compatible linker to link programs into an executable form.

There are several types of reference material you should have available as you pursue assembler mastery. You will certainly want a general reference on 8088 assembler. The 8086 Book, written by Rector and Alexy and published by Osborne/McGraw-Hill, is a good reference, although you should beware of its unusually high number of typographic errors. Also useful is the spiral-bound reference manual that comes with MASM, which contains an excellent summary of the instruction sets of the 8088, 8086, 80186, 80286, and 80386. IBM's hardware, BIOS, and DOS technical reference manuals are also useful references, containing as they do detailed information about the resources available to assembler programmers.

If you're the type who digs down to the hardware of the PC in the pursuit of knowledge, you'll find Intel's handbooks and reference manuals to be invaluable (albeit none too easy to read), since Intel manufactures the

8088 and many of the support chips used in the PC. There's simply no way to understand what a hardware component is capable of doing in the context of the PC without a comprehensive description of everything that part can do, and that's exactly what Intel's literature provides.

Finally, keep an eye open for articles on assembly-language programming. Articles provide a steady stream of code from diverse sources, and are your best sources of new approaches to assembler programming.

By the way, the terms "assembler" and "assembly-language" are generally interchangeable. While "assembly-language" is perhaps technically more accurate, since "assembler" also refers to the software that assembles assembly-language code, "assembler" is a widely-used shorthand that I'll use throughout this book. Similarly, I'll use "the Zen of assembler" as shorthand for "the Zen of assembly language."

ODDS AND ENDS

I'd like to identify the manufacturers of the products I'll refer to in this volume. Microsoft makes the Microsoft Macro Assembler (MASM), the Microsoft Linker (LINK), CodeView (CV), and Symdeb (SYMDEB). Borland International makes Turbo Assembler (TASM), Turbo C (TC), Turbo Link (TLINK), and Turbo Debugger (TD). SLR Systems makes OPTASM, an assembler. Finally, Orion Instruments makes OmniLab, which integrates high-performance oscilloscope, logic analyzer, stimulus generator, and disassembler instrumentation in a single PC-based package.

In addition, I'd like to point out that while I've made every effort to ensure that the code in this volume works as it should, no one's perfect. Please let me know if you find bugs. Also, please let me know what works for you and what doesn't in this book; teaching is not a one-way street. You can write me at:

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THE PATH TO THE ZEN OF ASSEMBLER

The Zen of Assembly Language consists of four major parts, contained in two volumes. Parts I and II are in this volume, Volume I, while Parts III and IV are in Volume II, The Zen of Assembly Language: The Flexible Mind. While the book you're reading stands on its own as a tutorial in high-performance assembler code, the two volumes together cover the whole of superior assembler programming, from hardware to implementation. I strongly recommend that you read both. The four parts of The Zen of Assembly Language are organized as follows.

Part I introduces the concept of the Zen of assembler, and presents the tools we'll use to delve into assembler code performance.

Part II covers various and sundry pieces of knowledge about assembler programming, examines the resources available when programming the PC, and probes fundamental hardware aspects that affect

code performance.

Part III (in Volume II) examines the process of creating superior code, combining the detailed knowledge of Part II with varied and often unorthodox coding approaches.

Part IV (also in Volume II) illustrates the Zen of assembler in the form of a working animation program.

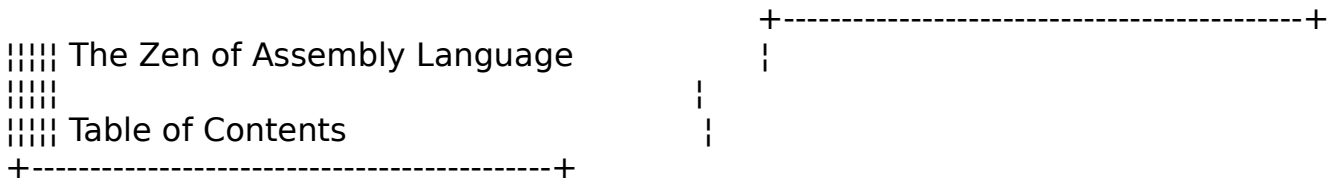
In general, Parts I and II discuss the raw stuff of performance, while Parts III and IV show how to integrate that raw performance with algorithms and applications, although there is considerable overlap. The four parts together teach all aspects of the Zen of assembler: concept, knowledge, the flexible mind, and implementation. Together, we will follow that path down the road to mastery of the IBM PC.

Shall we begin?

-- Michael Abrash

Sunnyvale, CA

May 29, 1989



PART I: THE ZEN OF ASSEMBLER

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Assembler is fundamentally different from other languages
Knowledge
The flexible mind
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