

x86-64

Assembly Language

Programming

with

Ubuntu



Ed Jorgensen, Ph.D.

Version 1.1.40

January 2020

Cover image:

Top view of an Intel central processing unit Core i7 Skylake type core, model 6700K, released in June 2015.

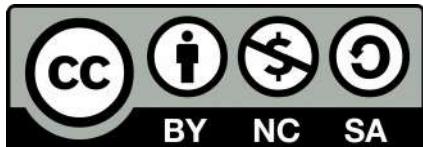
Source: Eric Gaba, https://commons.wikimedia.org/wiki/File:Intel_CPU_Core_i7_6700K_Skylake_top.jpg

Cover background:

By Benjamint444 (Own work)

Source: http://commons.wikimedia.org/wiki/File%3ASwirly_belt444.jpg

Copyright © 2015, 2016, 2017, 2018, 2019 by Ed Jorgensen



You are free:

To Share — to copy, distribute and transmit the work

To Remix — to adapt the work

Under the following conditions:

Attribution — you must attribute the work in the manner specified by the author or licensor (but not in any way that suggests that they endorse you or your use of the work).

Noncommercial — you may not use this work for commercial purposes.

Share Alike — if you alter, transform, or build upon this work, you may distribute the resulting work only under the same or similar license to this one.

Table of Contents

1.0 Introduction.....	1
1.1 Prerequisites.....	1
1.2 What is Assembly Language.....	2
1.3 Why Learn Assembly Language.....	2
1.3.1 Gain a Better Understanding of Architecture Issues.....	3
1.3.2 Understanding the Tool Chain.....	3
1.3.3 Improve Algorithm Development Skills.....	3
1.3.4 Improve Understanding of Functions/Procedures.....	3
1.3.5 Gain an Understanding of I/O Buffering.....	4
1.3.6 Understand Compiler Scope.....	4
1.3.7 Introduction Multi-processing Concepts.....	4
1.3.8 Introduction Interrupt Processing Concepts.....	4
1.4 Additional References.....	4
1.4.1 Ubuntu References.....	5
1.4.2 BASH Command Line References.....	5
1.4.3 Architecture References.....	5
1.4.4 Tool Chain References.....	5
1.4.4.1 YASM References.....	6
1.4.4.2 DDD Debugger References.....	6
2.0 Architecture Overview.....	7
2.1 Architecture Overview.....	7
2.2 Data Storage Sizes.....	8
2.3 Central Processing Unit.....	9
2.3.1 CPU Registers.....	10
2.3.1.1 General Purpose Registers (GPRs).....	10
2.3.1.2 Stack Pointer Register (RSP).....	12
2.3.1.3 Base Pointer Register (RBP).....	12
2.3.1.4 Instruction Pointer Register (RIP).....	12
2.3.1.5 Flag Register (rFlags).....	12
2.3.1.6 XMM Registers.....	13
2.3.2 Cache Memory.....	14
2.4 Main Memory.....	15
2.5 Memory Layout.....	17

Table of Contents

2.6	Memory Hierarchy.....	17
2.7	Exercises.....	19
2.7.1	Quiz Questions.....	19
3.0	Data Representation.....	21
3.1	Integer Representation.....	21
3.1.1	Two's Complement.....	23
3.1.2	Byte Example.....	23
3.1.3	Word Example.....	24
3.2	Unsigned and Signed Addition.....	24
3.3	Floating-point Representation.....	24
3.3.1	IEEE 32-bit Representation.....	25
3.3.1.1	IEEE 32-bit Representation Examples.....	26
3.3.1.1.1	Example → -7.75_{10}	26
3.3.1.1.2	Example → -0.125_{10}	26
3.3.1.1.3	Example → 41440000_{16}	27
3.3.2	IEEE 64-bit Representation.....	27
3.3.3	Not a Number (NaN).....	27
3.4	Characters and Strings.....	27
3.4.1	Character Representation.....	28
3.4.1.1	American Standard Code for Information Interchange.....	28
3.4.1.2	Unicode.....	29
3.4.2	String Representation.....	29
3.5	Exercises.....	29
3.5.1	Quiz Questions.....	30
4.0	Program Format.....	33
4.1	Comments.....	33
4.2	Numeric Values.....	33
4.3	Defining Constants.....	34
4.4	Data Section.....	34
4.5	BSS Section.....	35
4.6	Text Section.....	36
4.7	Example Program.....	37
4.8	Exercises.....	39
4.8.1	Quiz Questions.....	39
5.0	Tool Chain.....	41
5.1	Assemble/Link/Load Overview.....	41
5.2	Assembler.....	43

Table of Contents

5.2.1	Assemble Commands.....	43
5.2.2	List File.....	43
5.2.3	Two-Pass Assembler.....	45
5.2.3.1	First Pass.....	46
5.2.3.2	Second Pass.....	46
5.2.4	Assembler Directives.....	47
5.3	Linker.....	47
5.3.1	Linking Multiple Files.....	48
5.3.2	Linking Process.....	48
5.3.3	Dynamic Linking.....	49
5.4	Assemble/Link Script.....	50
5.5	Loader.....	51
5.6	Debugger.....	52
5.7	Exercises.....	52
5.7.1	Quiz Questions.....	52
6.0	DDD Debugger.....	55
6.1	Starting DDD.....	55
6.1.1	DDD Configuration Settings.....	57
6.2	Program Execution with DDD.....	57
6.2.1	Setting Breakpoints.....	57
6.2.2	Executing Programs.....	58
6.2.2.1	Run / Continue.....	60
6.2.2.2	Next / Step.....	60
6.2.3	Displaying Register Contents.....	60
6.2.4	DDD/GDB Commands Summary.....	62
6.2.4.1	DDD/GDB Commands, Examples.....	63
6.2.5	Displaying Stack Contents.....	65
6.2.6	Debugger Commands File (interactive).....	65
6.2.6.1	Debugger Commands File (non-interactive).....	66
6.2.6.2	Debugger Commands File (non-interactive).....	66
6.3	Exercises.....	67
6.3.1	Quiz Questions.....	67
6.3.2	Suggested Projects.....	68
7.0	Instruction Set Overview.....	69
7.1	Notational Conventions.....	69
7.1.1	Operand Notation.....	70
7.2	Data Movement.....	71

[Click here to download full PDF material](#)