Chapter 7 Assembly Language

7.1 Assembly Language Programming - Moving Up a Level

The purpose of assembly language is to make the programming process more user-friendly than programming in machine language, while still providing the programmer with detailed control over the instructions that the computer can execute.

Before a program written in a high-level language can be executed, it **must be translated into a program in the ISA** of the computer on which it is expected to execute. It is often the case that each statement in the high-level language specifies **several instructions in the ISA** of the computer.

7.2 An Assembly Language Problem

7.2.1 Instructions

```
LABEL   Opcode  Operands    ; Comment
```

7.2.1.1 Opcodes & Operands

These two parts are mandatory(强制的).

The **Opcode** is a symbolic name for opcode of the corresponding LC-3 instruction.

The number of **operands** depends on the operation being performed.

7.2.1.2 Labels

Labels are symbolic names that are used to identify memory locations that are referred to explicitly in the program.

2 reasons for using Labels:*

- The location is the target of a branch instruction.
- The location contains a value that is loaded or stored.

7.2.1.3 Comments

Comments are messages intended only for human consumption.

7.2.2 Pseudo-Ops

7.2.2.1 .ORIG

It tells the assembler where in the memory to place the LC-3 program.

7.2.2.2 .FILL

It tells the assembler to set aside the next location in the program and initialize it with the value of the operand.

7.2.2.3 .BLKW

(a **BL**oc**K** of **W**ords)

It tells the assembler to set aside some number of sequential memory locations in the program.

7.2.2.4 .STRINGZ

It tells the assembler to initialize a sequence of $n+1$ memory locations. The first n words of memory are initialized with the zero-extended ASCII codes of the corresponding characters in the string. The final word of memory is initialized to 0.

7.2.2.5 .END

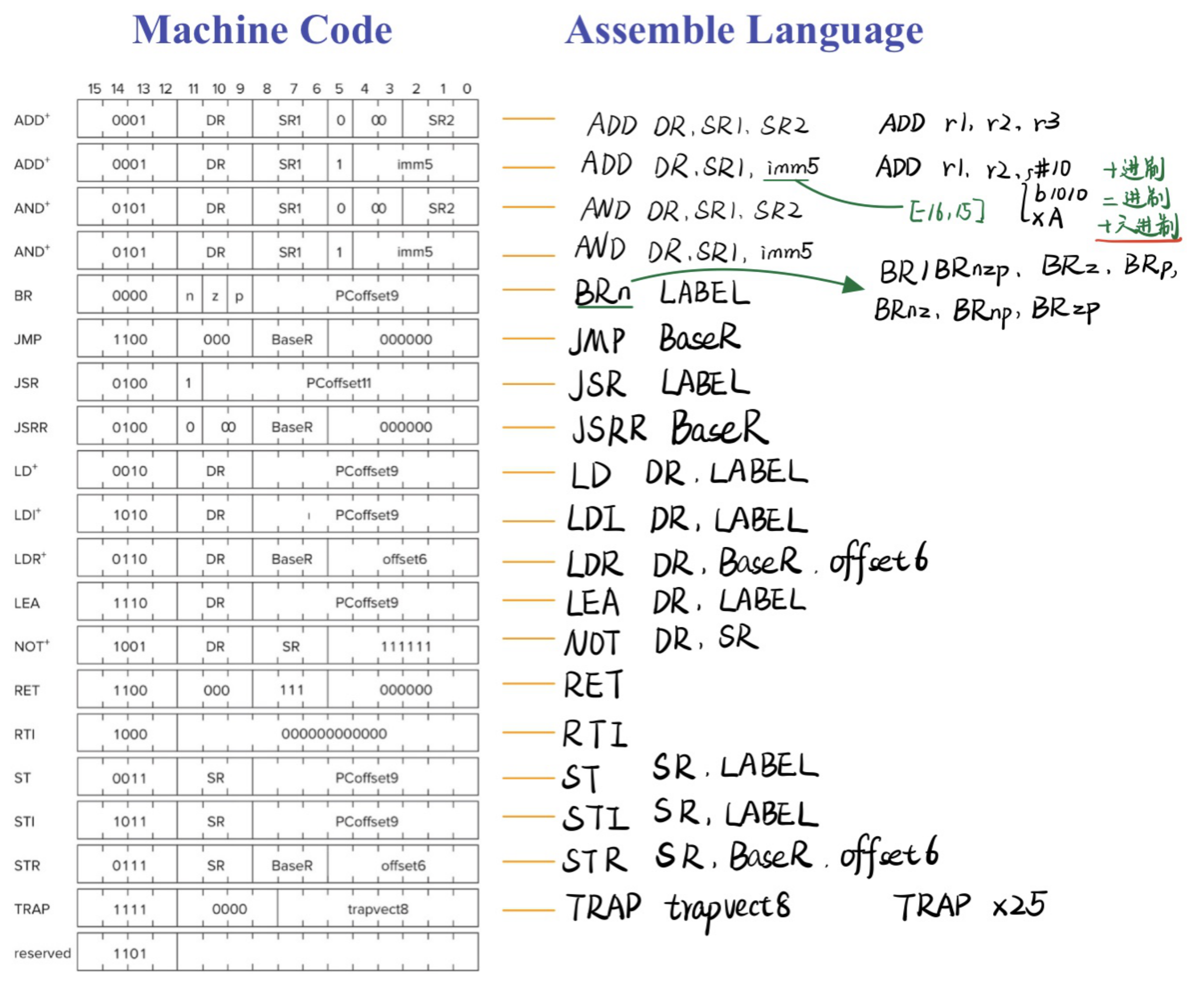
It tells the assembler it has reached the end of the program and need not even look at anything after it.

HINT: .END does not stop the program **&** it does not even exist at the time of execution.

*(in 7.4.2) .EXTERNAL

It send a message to LC-3 assembler that the absence of the label corresponding to the pseudo-ops is not an error.

Used for multi-file programming.



Machine Code — **Assemble Language**

	15 14 13 12	11	10	9	8 7 6	5	4 3	2 1 0	Assemble Language	
ADD⁺	0001	DR			SR1	0	00	SR2	ADD DR, SR1, SR2	ADD r1, r2, r3
ADD⁺	0001	DR			SR1	1	imm5		ADD DR, SR1, imm5	ADD r1, r2, #10 (十进制); b1010 (二进制); xA (十六进制); imm5: [-16, 15]
AND⁺	0101	DR			SR1	0	00	SR2	AND DR, SR1, SR2	
AND⁺	0101	DR			SR1	1	imm5		AND DR, SR1, imm5	
BR	0000	n	z	p	PCoffset9				BRn LABEL	BR / BRnzp, BRz, BRp, BRnz, BRnp, BRzp
JMP	1100	000			BaseR	000000			JMP BaseR	
JSR	0100	1	PCoffset11						JSR LABEL	
JSRR	0100	0	00		BaseR	000000			JSRR BaseR	
LD⁺	0010	DR			PCoffset9				LD DR, LABEL	
LDI⁺	1010	DR			PCoffset9				LDI DR, LABEL	
LDR⁺	0110	DR			BaseR	offset6			LDR DR, BaseR, offset6	
LEA	1110	DR			PCoffset9				LEA DR, LABEL	
NOT⁺	1001	DR			SR	111111			NOT DR, SR	
RET	1100	000			111	000000			RET	
RTI	1000	000000000000							RTI	
ST	0011	SR			PCoffset9				ST SR, LABEL	
STI	1011	SR			PCoffset9				STI SR, LABEL	
STR	0111	SR			BaseR	offset6			STR SR, BaseR, offset6	
TRAP	1111	0000			trapvect8				TRAP trapvect8	TRAP x25
reserved	1101									

Pseudo-Ops:

.ORIG x3000	.BLKW 2
.FILL xFFFF	.STRINGZ "Hello World"
.END	.EXTERNAL START of FILE *

7.3 The Assembly Process

7.3.2 A Two-Pass Process

The First Pass: Creating the Symbol Table

The Second Pass: Generating the Machine Language Program

7.4 Beyond the Assembly of a Single Assembly Language Program *(Recommend Reading)*

The concept of The Executable Image

Multi-file programming