Lecture: 3

WORKING WITH OPERATORS, INSTRUCTIONS & SYMBOLIC CONSTANTS

Objectives:

- Assembly Language Instruction: MOV, ADD, SUB, INC, DEC, MOVZX, MOVSX, XCHG
- Symbolic Constants
- Example Program

Section 01 | Assembly Language Instruction: MOV, ADD, SUB, INC, DEC, MOVZX, MOVSX, XCHG

x86 Instruction Format:

```
[label:] mnemonic [operands][;comment]
```

Because the number of operands may vary, we can further subdivide the formats to have zero, one, two, or three operands.

Here, we omit the label and comment fields for clarity:

```
mnemonic

mnemonic [destination]

mnemonic [destination],[source]

mnemonic [destination],[source-1],[source-2]
```

x86 assembly language uses different types of instruction operands. The following are the easiest to use:

- Immediate—uses a numeric literal expression.
- Register—uses a named register in the CPU.
- Memory—references a memory location.

Following table lists a simple notation for operands. We will use it from this point on to describe the syntax of individual instructions.

Operand	Description
reg8	8-bit general-purpose register: AH, AL, BH, BL, CH, CL, DH, DL
reg16	16-bit general-purpose register: AX, BX, CX, DX, SI, DL SP, BP
reg32	32-bit general-purpose register: EAX, EBX, ECX, EDX, ESI, EDI, ESP, EBP
reg	Any general-purpose register
sreg	16-bit segment register: CS, DS, SS, ES, FS, GS
imm	8-, 16-, or 32-bit immediate value
imm8	8-bit immediate byte value
imm16	16-bit immediate word value
imm32	32-bit immediate double word value
reg/mem8	8-bit operand, which can be an 8-bit general register or memory byte
reg/mem16	16-bit operand. which can be a 16-bit general register or memory word
reg/mem32	32-bit operand, which can be a 32-bit general register or memory double word
mem	An 8-, 16-, or 32-bit memory operand

MOV Instruction

It is used to move data from source operand to destination operand.

- Both operands must be the same size.
- Both operands cannot be memory operands.
- CS, EIP, and IP cannot be destination operands.
- An immediate value cannot be moved to a segment register.

Syntax:

```
MOV destination, source
```

Here is a list of the general variants of MOV, excluding segment registers:

Examples

```
MOV bx, 2
MOV ax, cx
```

Examples

'A' has ASCII code 65D (01000001B, 41H)

The following MOV instructions stores it in register BX:

```
MOV bx, 65d
MOV bx, 41h
MOV bx, 01000001b
MOV bx, 'A'
```

All of the above are equivalent.

Examples

The following examples demonstrate compatibility between operands used with MOV instruction:

```
MOV ax, 2          ✓
MOV 2, ax          ✗
MOV ax, var        ✓
MOV var, ax        ✓
MOV var1, var2     ✗
MOV 5, var         ✗
```

Overlapping Values

Examples

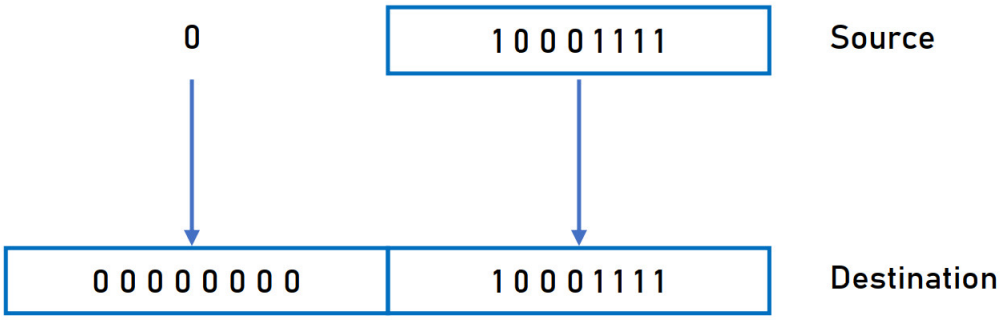
```
.data
     oneByte BYTE 78h
     oneWord WORD 1234h
     oneDword DWORD 12345678h
.code
     mov eax, 0            ; EAX = 00000000h
     mov al, oneByte       ; EAX = 00000078h
     mov ax, oneWord       ; EAX = 00001234h
     mov eax, oneDword     ; EAX = 12345678h
     mov ax, 0             ; EAX = 12340000h
```

MOVZX Instruction

The MOVZX (MOV with zero-ex tend) instruction moves the contents and zero-extends the value to 16 or 32 bits. This instruction is only used with unsigned integers.

Syntax:

```
MOVZX reg32, reg/mem8
MOVZX reg32, reg/mem16
MOVZX reg16, reg/mem8
```



The following examples use registers for all operands, showing all the size variations:

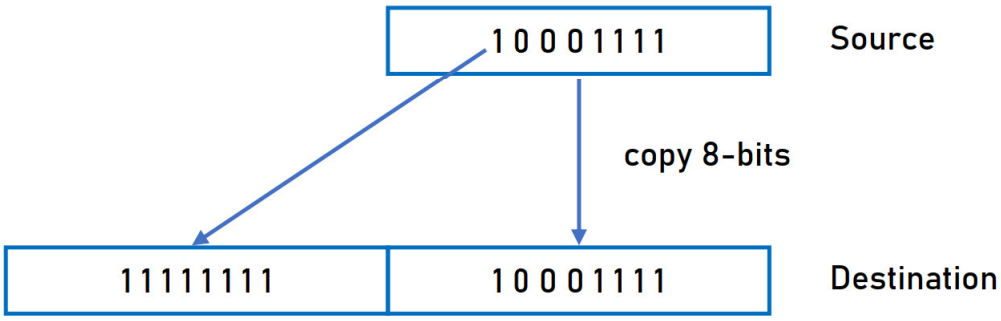
```
mov bx, 0A69Bh
mov bl, 09Bh
movzx eax, bx   ; EAX = 0000A69Bh
movzx edx, bl   ; EDX = 0000009Bh
movzx cx, bl    ; CX = 009Bh
```

The following examples use memory operands for the source and produce the same results:

```
.data
     byte1 BYTE 9Bh
     word1 WORD 0A69Bh
.code
     movzx eax, word1      ; EAX = 0000A69Bh
     movzx edx, byte1      ; EDX = 0000009Bh
     movzx ex, byte1       ; CX = 009Bh
```

MOVSX Instruction

The MOVSX (MOV with sign extend) instruction moves the contents and sign extends the value to 16 or 32 bits. This instruction is only used with signed integers.



The following examples use registers for all operands, showing all the size variations:

```
mov bx, 0A69Bh
movsx eax, bx   ; EAX = FFFFA69Bh
movsx edx, bl   ; EDX = FFFFFF9Bh
mov bl, 7Bh     ; BL = 7Bh
movsx cx, bl    ; CX = 007Bh
```

INC Instruction

The INC instruction takes an operand and adds 1 to it.

Example

```
mov ax, 8
inc ax     ; ax now contains 9
```

DEC Instruction

The DEC instruction takes an operand and subtracts 1 from it.

Example

```
mov ax, 5
dec ax     ; ax now contains 4
```

XCHG Instruction

The XCHG (exchange data) instruction exchanges the contents of two operands. XCHG does not accept immediate operands. There are three variants:

```
xchg reg, reg
xchg reg, mem
xchg mem, reg
```

To exchange two memory operands, use a register as a temporary container and combine MOV with XCHG:

```
mov ax, val1
xchg ax, val2
mov val1, ax
```

ADD Instruction

The ADD instruction adds a source operand to a destination operand of the same size. Source is unchanged by the operation, and the sum is stored in the destination operand.

Syntax:

```
ADD dest, source
```

SUB Instruction

The SUB instruction subtracts a source operand from a destination operand.

Syntax:

```
SUB dest,source
```

NEG Instruction

The NEG (negate) instruction reverses the sign of a number by converting the number to its two's complement. The following operands are permitted:

```
NEG reg
NEG mem
```

Section 02 | Symbolic Constant

A symbolic constant (or symbol definition) is created by associating an identifier (a symbol) with an integer expression or some text. Symbols do not reserve storage. They are used only by the assembler when scanning a program, and they cannot change at runtime.

1. Equal-Sign (=) Directive

   The equal-sign (=) directive associates a symbol name with an integer expression

   Syntax:

   ```
   name = expression
   ```

   Example

   ```
   COUNT = 500
   mov eax, COUNT
   mov eax, 500
   ```

   Redefinitions: A symbol defined with can be redefined within the same program. The following example shows how the assembler evaluates COUNT as it changes value:

   ```
   COUNT = 5
   mov al, COUNT   ; al = 5
   COUNT = 10
   mov al, COUNT   ; al = 10
   ```

2. EQU Directive

   The EQU directive associates a symbolic name with an integer expression or some arbitrary text. Ordinarily, expression is a 32-bit integer value. When a program is assembled, all occurrences of name are replaced by expression during the assembler's preprocessor step.

   Syntax:

   ```
   name EQU expression
   name EQU symbol
   name EQU <text>
   ```

   - Expression must be a valid integer expression.
   - Symbol is an existing symbol name, already defined with = OR EQU.
   - Any text may appear with the brackets <….>.

   Example

   ```
   matrix1 EQU 10 * 10
   matrix2 EQU <10 * 10>
   .data
        M1 WORD matrix1
        M2 WORD matrix2
   ```

The assembler produces different data definitions for M1 and M2. The integer expression in matrix1 is evaluated and assigned to M1. On the other hand, the text in matrix2 is copied directly into the data definition for M2.

```
M1 WORD 100
M2 WORD 10 * 10
```

Section 03 | Example Program

The following program implements various arithmetic expressions using the ADD, SUB, and NEG instructions.

```
INCLUDE Irvine32.inc

; Rval = -Xval + (Yval - Zval)
; The following signed 32-bit variables will be used:

.data
     Rval SDWORD ?
     XVAL SDWORD 26
     Yval SDWORD 30
     Zval SDWORD 40

.code
     main PROC

          ; first term: -Xval
          mov EAX, Xval
          neg EAX              ; EAX = -26

; then Yval is copied to a register and Zval is subtracted:

          ; second term: (Yval - Zval)
          mov EBX, Yval
          sub ebx, Zval        ; EBX = -10

; finally, the two terms (in EAX and EBX) are added:

          ; add the terms and store:
          add EAX, EBX
          mov Rval, EAX        ; Rval = -36
          mov EAX, Rval

          call WriteInt
          exit
     main ENDP
END main
```