Lecture 11: Addressing Modes (Part 1)

- Operand Types (a review)
- Addressing Modes
- WORD and BYTE PTR

Basic Operand Types

- Three basic types:
  - immediate – a constant
  - register – a CPU register
  - memory – a reference to a location in memory

Immediate Operands

- An immediate operand is a constant expression such as a number, a character, or an arithmetic expression.

```
mov  al, 10         ; al = 10
mov  bl, ‘A’        ; bl = ‘A’
mov  cx, ‘AB’       ; cx = ‘AB’
mov  dx, 123h       ; dx = 123h
```

- The assembler calculates the value of the immediate operand and inserts it directly into the machine instruction.

Register Operands

- As we’ve seen, register operands are eight or sixteen bit registers (or 32 if using the extended registers).

```
mov        ax, bx
mov        al, bl
```

- Register addressing is very efficient because no memory access is required.

Memory Operands

- For memory operands, there are a number of different ways that they can be accessed using assembly language.
- These different ways are *addressing modes*.

Assembly Language Addressing Modes

- Memory is accessed by calculating its *effective address*, using the distance (or offset) of the data from the beginning of a segment (usually the data segment).

- Memory Addressing modes:

  Direct
  Register Indirect
  Based or Indexed
  Base-indexed
  Base-indexed with displacement (displacement is a number or offset from a variable)

Direct Operands

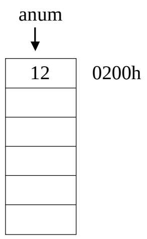
- A direct operand refers to the contents of memory at a location identified by a label in the data segment.
- We’ve seen many examples of this already. Here are a few more:
  - Irvine, p. 78

OFFSET Operator

The *offset operator* is used to move the offset of a label into a register or variable.

```
anum    db      12
        .
        .
        mov     bx, offset anum

-- assembles as:
        mov     bx, 0200h
```



Why is this useful?

In homework 2 we saw how storing an address in BX could be used to step through a list of numbers.

Another way to get the address

- LEA   BX, anum
- LEA stands for load effective address
- There is a difference between LEA and MOV … OFFSET:
  - LEA calculates the label's offset at *runtime*
  - MOV … OFFSET moves an immediate value that is known at *assembly time*
- Use LEA if the effective address of an operand *must* be calculated at runtime.

Direct-Offset Operands

- You can use the addition and subtraction operators to access a list of values.
  - The + operator adds to the offset of a variable.
  - The minus operator subtracts from the labels offset.

Addition Example

- Irvine, p. 79

Subtraction Example

- p. 76 in Irvine

- Where have we seen this type of addressing before?

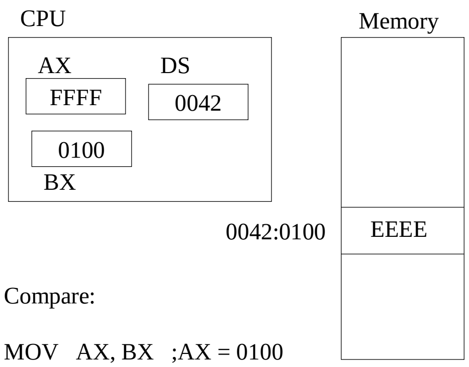
Lecture 7 Example of Direct Offset Addressing

- Example:

```
arrayB   db  10h, 20h
arrayW   dw 100h, 200h
….
mov al, arrayB    ;AL = 10h
mov al, arrayB+1  ;AL = 20h
mov ax, arrayW    ;AX = 100h
mov ax, arrayW+2  ;AX = 200h
mov ax, arrayW+1  ;AX = ?
```

Indirect Addressing

- An indirect operand is a register that contains the offset of data in memory.
- When the offset of the variable is placed in a register, the register becomes a pointer to the label.
- You can use SI, DI, BX, and BP to hold indirect operands.
  - BX: base register
  - SI, DI: index registers
  - BP: base pointer (contains an offset from the SS register)



Compare:

```
MOV   AX, BX   ;AX = 0100
MOV   AX, [BX]  ; AX = EEEE
```

So why do we have to use indirect addressing? We could just put a label at location 0042:0100 and do a

```
MOV   AX, label
```

```
;increment each word in an array list
    .data
LIST    DW     5FFFh, 0Ah, 12h, 17h, 4h
    .code
    .startup
;step through each element and increment
    MOV         AX, LIST
    INC AX
    MOV         LIST, AX
    MOV         AX, LIST+2
    INC AX
    MOV         LIST+2, AX
etc… for list+4, list+6, list+8
```

- This could get pretty long! You need a way to modify the address at *execution time* so you can put the above code in a loop.

- If you put the address of the base of the list in BX, you can use indirect addressing and a loop!

```
;increment each word in an array list
     .data
LIST      DW        5FFFh, 0Ah, 12h, 17h, 4h
     .code
     .startup
     MOV  BX, offset LIST
     MOV  CX, 5               ;5 elements
LUP: MOV AX, [BX]       ; get item pointed to by BX
     INC  AX                  ;add one to it
     MOV  [BX], AX            ;put back into same place
     ADD  BX, 2               ;increment address by 2
     LOOP LUP                 ;loop back to top
```

- Quite an improvement!

An even shorter way!

```
;increment each word in an array list
     .data
LIST      DW        5FFFh, 0Ah, 12h, 17h, 4h
     .code
     .startup
               LEA      BX, LIST
               MOV      CX, 5
LUP:           INC WORD PTR [BX]       ;*
               ADD BX, 2
               LOOP LUP
```

- * You can't just say INC [BX] because there is nothing in the instruction to indicate if BX has the address of a word (like in this example) or a byte.
- You can specify which one it is using WORD PTR or BYTE PTR

More on WORD and BYTE PTR

```
;increment each word in an array list
     .data
LIST      DW        5FFFh, 0Ah, 12h, 17h, 4h
     .code
     .startup
               LEA      BX, LIST
               MOV      CX, 5
LUP:           INC WORD PTR [BX]     ; List's 1st entry
                                      ;after INC would
                                      ;be 6000h
          vs.
….
LUP:      INC BYTE PTR [BX]          ;Lists 1st entry
                                      ;after INC would
                                      ;be 5F00h
```

only the low byte (FF) was incremented. It wrapped around from FF back to 0; the upper byte was unaffected.

- So, the pointer is the same (always addresses a byte) but if declared as a word pointer, the operation is done on a 16-bit value; if a byte pointer, on an 8-bit value.
- You wouldn't need to make a distinction for:

  MOV AX, [DI]
- Why?
  - The use of AX indicates that DI should be treated as a word pointer.

We've seen indirect addressing before!

- Remember homework 2 with our array of numbers:
  - -14 = 0FFF2h
  - 0 = 0000h
  - -6 = 0FFFAh
  - -42 = 0FFD6h
  - 17 = 0011h
  - 2 = 0002h
- We used BX as a pointer to each element in the array in order to step through and add them up (in part 1).
- We used DX as a pointer to the last element in the array and compared it to BX in order to tell if we were done.
- DS pointed to the start of the data segment.

EA	Data	Offset from DS
1C554	F2	0004
1C555	FF	0005
1C556	00	0006
1C557	00	0007
1C558	FA	0008
1C559	FF	0009
1C55A	D6	000A
1C55B	FF	000B
1C55C	11	000C
1C55D	00	000D
1C55E	02	000E
1C55F	00	000F

DS	1C55	
BX		address of 1st word
DX		address of last word

Data	Offset from DS
F2	0004
FF	0005
00	0006
00	0007
FA	0008
FF	0009
D6	000A
FF	000B
11	000C
00	000D
02	000E
00	000F

```
mov  bx, 0004h
mov  ax, [bx]    ; ax = FFF2
add   bx, 2      ; bx = 0006
mov   ax, [bx]   ; ax = 0000
add   bx, 2      ; bx = 0008
mov   ax, [bx]   ; ax = fffa
add   bx, 2      ; bx = 000A
mov   ax, [bx]   ; ax = ffd6
add   bx, 2      ; bx = 000C
mov   ax, [bx]   ; ax = 0011
add    bx, 2     ; bx = 000E
mov    ax, [bx]  ; ax = 0002
```

BX serves as a pointer into the array. In HW2, we used compare and conditional jumps to traverse the array in a loop.

Not just to access words.

- example from p. 106, Irvine

Segment Defaults

- The offset created by an indirect operand is assumed to be from DS unless BP (or EBP) is part of the indirect operand.
- If BP is involved, then the offset is from the stack segment (SS register).
- You can override the default segment if necessary:

```
mov   al, cs:[si] ;offset from CS
```

Another Example

- Example 3, part 1 from Irvine p. 107

Example, continued

- You can avoid the separate instructions that increment BX:
- Example 3 from Irvine, part 2, p. 108

- This takes advantage of sum being stored after the data. This is NOT a good approach!