Faculty of Computing

Year 1 Semester 1 (2024)

IIT1140 – Fundamental of Computing Lab Sheet 02

Objectives:

1. *To understand the Assembly programming concepts.*
2. *Apply the assembly syntaxes for branching and looping to implement a working program.*

Branching Instructions in Assembly Language

Several branching instructions accomplish conditional execution in assembly language. These instructions can change the flow of control in a program. We can simulate **if-else** conditions supported by higher-level programming languages using **CMP** and **branching** instructions. **Branching** instruction is observed in two scenarios namely Unconditional Jump and Conditional Jump.

1. **Unconditional Jump**

   This is performed by the JMP instruction. Conditional execution often involves a transfer of control to the address of an instruction that does not follow the currently executing instruction. Transfer of control may be forward, to execute a new set of instructions or backward, to re-execute the same steps.

   The JMP instruction provides a label name where the flow of control is transferred immediately. The syntax of the JMP instruction is,

   JMP label

   Example:

```
1  Label1;
2  MOV dl, 'a'  // Initializing dl to a
3  MOV ah, 02   // Initializing ah to 2
4  ADD dl, ah   // Add dl, ah
5  JMP Label1  // repeats the statements
```

Figure 2.1

Once the **JMP** instruction is executed, the control will transfer to the line which **Label1** specified. There is no condition evaluated in JMP statement. This is commonly used in loops, subroutine calls, and error-handling routines.

2. **Conditional jump**

This is performed by a set of jump instructions depending upon the condition. A conditional jump transfers the execution to a specified location only if a certain condition is met, based on the status flags set by previous instructions (e.g., zero flag, carry flag). There are numerous conditional jump instructions depending on the condition and data. The syntax of this instruction is,

```
J<condition> label
```

2.1 Conditional jump instructions used on signed data used for arithmetic operations.

Instruction	Description	Condition	Opposite Instruction
JE , JZ	Jump if Equal (=). Jump if Zero.	ZF = 1	JNE, JNZ
JNE , JNZ	Jump if Not Equal (<>). Jump if Not Zero.	ZF = 0	JE, JZ
JG , JNLE	Jump if Greater (>). Jump if Not Less or Equal (not <=).	ZF = 0 and SF = OF	JNG, JLE
JL , JNGE	Jump if Less (<). Jump if Not Greater or Equal (not >=).	SF <> OF	JNL, JGE
JGE , JNL	Jump if Greater or Equal (>=). Jump if Not Less (not <).	SF = OF	JNGE, JL
JLE , JNG	Jump if Less or Equal (<=). Jump if Not Greater (not >).	ZF = 1 or SF <> OF	JNLE, JG

Figure 2.2

2.2 Conditional jump instructions used on unsigned data used for logical operations.

Instruction	Description	Condition	Opposite Instruction
JE , JZ	Jump if Equal (=). Jump if Zero.	ZF = 1	JNE, JNZ
JNE , JNZ	Jump if Not Equal (<>). Jump if Not Zero.	ZF = 0	JE, JZ
JA , JNBE	Jump if Above (>). Jump if Not Below or Equal (not <=).	CF = 0 and ZF = 0	JNA, JBE
JB , JNAE, JC	Jump if Below (<). Jump if Not Above or Equal (not >=). Jump if Carry.	CF = 1	JNB, JAE, JNC
JAE , JNB, JNC	Jump if Above or Equal (>=). Jump if Not Below (not <). Jump if Not Carry.	CF = 0	JNAE, JB
JBE , JNA	Jump if Below or Equal (<=). Jump if Not Above (not >).	CF = 1 or ZF = 1	JNBE, JA

Figure 2.3

2.3 **Conditional jump instructions have special uses and check the value of flags.**

Instruction	Description	Condition	Opposite Instruction
JZ , JE	Jump if Zero (Equal).	ZF = 1	JNZ, JNE
JC , JB, JNAE	Jump if Carry (Below, Not Above Equal).	CF = 1	JNC, JNB, JAE
JS	Jump if Sign.	SF = 1	JNS
JO	Jump if Overflow.	OF = 1	JNO
JPE, JP	Jump if Parity Even.	PF = 1	JPO
JNZ , JNE	Jump if Not Zero (Not Equal).	ZF = 0	JZ, JE
JNC , JNB, JAE	Jump if Not Carry (Not Below, Above Equal).	CF = 0	JC, JB, JNAE
JNS	Jump if Not Sign.	SF = 0	JS
JNO	Jump if Not Overflow.	OF = 0	JO
JPO, JNP	Jump if Parity Odd (No Parity).	PF = 0	JPE, JP

Figure 2.4

This is used for decision-making processes in the code, such as if-else statements, loops, and comparisons.

Below is a summary of the conditional and unconditional jump instructions.

Feature	Unconditional Jump (JMP)	Conditional Jump (e.g., JE, JNE)
Control Transfer	Always	Only if the specified condition is met
Usage Scenarios	Loops, subroutines, errors	If-else, comparisons, decision making
Dependence on Flags	No	Yes, depends on the status flags set by previous instructions
Predictability	Predictable, always jumps	Conditional, may or may not jump
Complexity	Simple	Slightly more complex due to condition checks

3. CMP Instruction

The **CMP** instruction compares two operands. It is generally used in conditional execution. This instruction basically subtracts one operand from the other to compare whether the operands are equal or not. It does not disturb the destination or source operands. It is used along with the conditional jump instruction for decision-making. The syntax of the CMP instruction is,

```
CMP destination, source
```

CMP compares two numeric data fields. The destination operand could be either in the register or in memory. The source operand could be a constant (immediate) data, register, or memory.

Example:

```
1  CMP DX, 00;      //Compare the DX value with zero
2  JE  L7;          //If yes, then jump to label L7
```

Figure 2.5

Activity 1:

a) Consider the Assembly code given in figure 2.6. Explain the purpose of each statement.

```
1  MOV AL, 80h
2  MOV BL, 7Fh
3  CMP AL, BL
4  JG EXIT
```

Figure 2.6

Line 1: This line means move the hexa decimal value of the 80(80H) into AL register.

Line 2: this line means move the hexa decimal value of the 7F(7FH) into BL register.

Line 3: This instruction takes two operands (ALregister, BLregister) and subtracts one from the other
Then sets OF, SF, ZF, AF, PF and CF flags Accordingly. (the operand 1 can be a register or memory address and operand 2 can be a register, memory or immediate value)

Line 4: According to the 3rd line if the value in AL register greater than BL register then the comment will come true. then it jumps to the label "exit" .if it is false the program continues to the next instruction.

b) Will the **"JG"** instruction in the following code result in a jump? (Yes/ No):

Yes

Activity 2:

Refer to the Assembly code given in figure 2.7. Will the program jump to the ***"GreaterThan"*** label? Explain the reason for your answer.

```
1  MOV AX, 10
2  MOV BX, 5
3  CMP AX, BX
4  JG GreaterThan
```

Figure 2.7

Yes, The program will jump to the greater than

The first line (MOV AX, 10) moves the value of the 10 into AX register. The second line (MOV BX, 5) moves the value of the 5 into BX register then With the CMP commend the two operands (AX register and BX register) are compare one from the other. The value of the AX=10 and the value of the BX=5
10>5
AX>BX
So, the greater than jump to the greater than.

Activity 3:

Consider the Assembly code given in figure 2.8 and briefly explain it.

```
MOV AX, 10
ADD AX, 5
JMP Exit

Loop:
  ; Code to be executed repeatedly

Exit:
  ; Code to execute after the loop
```

Figure 2.8

Move the value 10 into AX register Next add the value 5 to the AX register. Now the AX register contains the value 15. Then the program jump to the exit when skip over the code in the loop section. Loop label is a section of code intended to be repeated. However, in this case, the code here is skipped because of the jump. The Exit label will execute the code here after skipping the "Loop" section.

Looping Instructions in Assembly Language

Loops can also be used in assembly language, but unlike higher-level languages, it doesn't offer various loop types. Although the emu8086 emulator supports five loop syntaxes: LOOP, LOOPE, LOOPNE, LOOPNZ, and LOOPZ, they often lack the flexibility needed for many situations. Instead, we can create custom loops such as for, while, do-while using condition and jump statements.

LOOP instructions are used to execute a statement or set of statements for a specific number of times. The syntax is;

```
LOOP <Label_Name>
```

For Loop

A for loop contains three key parts: an initialization section where loop variables are set, a loop condition section determining if the loop should continue, and an increment/decrement section updating loop variables before the next iteration.

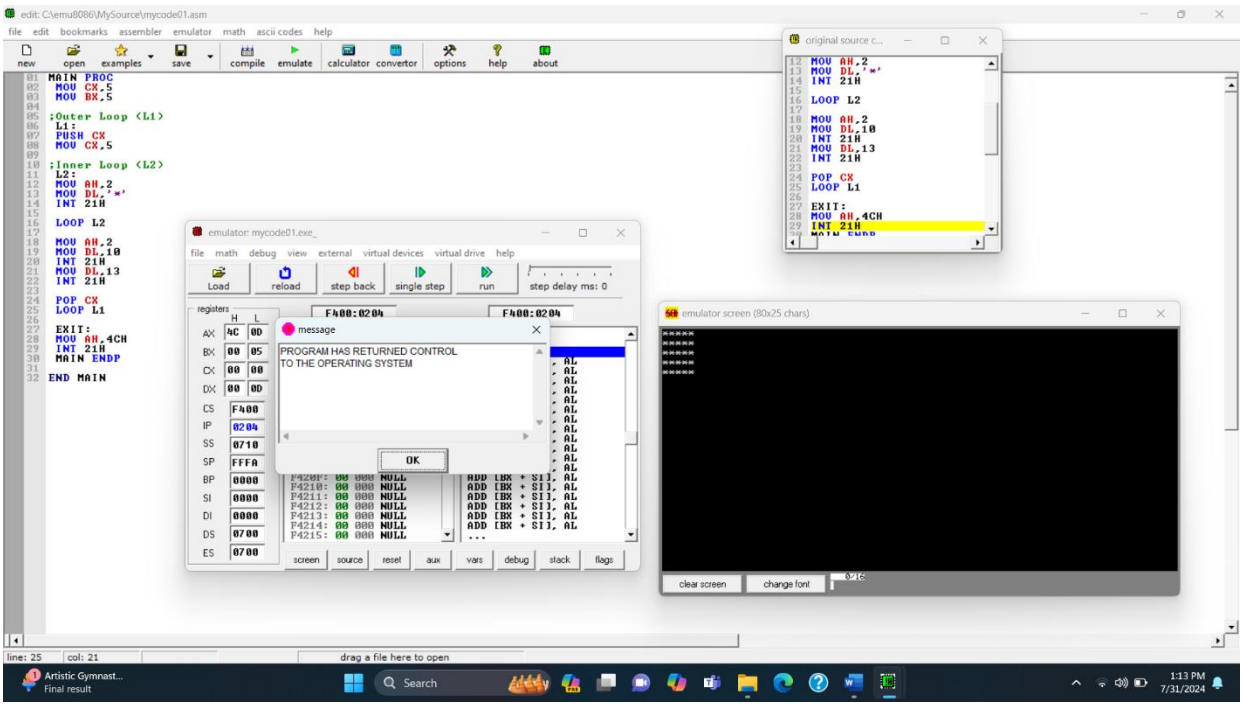
Activity 4:

The Assembly code to print a square of star (*) pattern series of 5 rows is given in figure 2.9. Execute this and understand the procedure.

```
*****
*****
*****
*****
*****
```

```
MAIN PROC
    MOV CX,5
    MOV BX,5

; Outer Loop (L1)
    L1:
    PUSH CX
    MOV CX,5

; Inner Loop (L2)
    L2:
     MOV AH,2
     MOV DL,'*'
     INT 21H

     LOOP L2

     MOV AH,2
     MOV DL,10
     INT 21H
     MOV DL,13
     INT 21H

    POP CX
    LOOP L1

    EXIT:
    MOV AH,4CH
    INT 21H
    MAIN ENDP

END MAIN
```

Figure 2.9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file edit bookmarks assembler emulator math ascii codes help
new open examples save compile emulate calculator convertor options help about
MAIN PROC
MOV CX,5
MOV BX,5
;Outer Loop (L1)
L1:
PUSH CX
MOV CX,5
;Inner Loop (L2)
L2:
MOV AH,2
MOV DL,'*'
INT 21H
LOOP L2
MOV AH,2
MOV DL,10
INT 21H
MOV DL,13
INT 21H
POP CX
LOOP L1
EXIT:
MOV AH,4CH
INT 21H
MAIN ENDP
END MAIN
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emulator: mycode01.exe_
file math debug view external virtual devices virtual drive help
Load reload step back single step run step delay ms: 0
registers
F400:0204
message
PROGRAM HAS RETURNED CONTROL
TO THE OPERATING SYSTEM
OK
screen source reset aux vars debug stack flags
emulator screen (80x25 chars)
clear screen change font
line: 25 col: 21
drag a file here to open
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Final result
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1:13 PM
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Activity 5: Write the Assembly code to print a square pattern of 4 rows as given below.

++++
++++
++++
++++

```
MAIN PROC
  MOV CX, 5
  MOV BX, 5
; Outer Loop (L1)
  L1:
  PUSH CX
  MOV CX, 5
; Inner Loop (L2)
  L2:
  MOV AH, 2
  MOV DL, '*'
  INT 21H
  LOOP L2
  MOV AH, 2
  MOV DL, 10
  INT 21H
  MOV DL, 13
  INT 21H
  POP CX
  LOOP L1
  EXIT:
  MOV AH, 4CH
```

```
    INT 21H

    MAIN ENDP

END MAIN
```