

Flow Control Instructions

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Course Title: Computer Organization and Architecture



Dept. of Computer Science
Faculty of Science and Technology

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Lecture Outline



Decision making and repeating statement

Jump and loop instructions

Algorithm conversion to assembly language

High-Level Language Structures

Jump and Loop



Jump and Loop instructions transfers control to another program

The transfers can be unconditional or

Depends on a particular combination of status flags settings

Conversion of algorithm is easier in assembly

Example of Jump



```
.MODEL SMALL
.STACK 100
.DATA
.CODE
MAIN PROC
MOV AH,2
MOV CX,256
MOV DL,0 ;ASCII of null
```

```
PRINT_LOOP:
INT 21H
INC DL
DEC CX
JNZ PRINT_LOOP
MOV AH,4CH
INT 21H
MAIN ENDP
END MAIN
```

JNZ (Jump if Not Zero)



JNZ is the instruction that controls loop.

If result of preceding instruction is not Zero Then the JNZ transfers the control to the instruction at label PRINT_LOOP.

If the preceding instruction contains zero (i.e. CX=0) then the program goes to execute DOS return instructions.

PRINT_LOOP is the first statement label

Labels are needed to refer another instruction

Labels end with colon (:))

Labels are placed on a line by themselves to make it stand out.

Conditional Jumps



JNZ is an example of Conditional Jump Instruction:

JXXX destination_label

if the condition for the jump is true, the next instruction to be executed is at **destination_label**

If condition is false, the instruction following the jump is done next.

i.e. for JNZ if the preceding instruction is non-zero

Implementation of Conditional JUMP by CPU



The CPU looks at the FLAGS register (it reflects the result of last thing that processor did)

If the conditions for the jump (combination of status flag settings) are true, the CPU adjusts the IP to point to the destination label.

The instruction at this label will be done next.

If the jump condition is false, then IP is not altered and naturally the next instruction is performed.

Example(cont'd...)



In the previous example:

The JNZ PRINT_LOOP is executed by inspecting ZF

If ZF=0 then control is transferred to PRINT_LOOP and continues

If the ZF=1 then the program goes on to execute next (i.e. MOV AH,4CH)

CMP Instruction



CMP destination , source

Compares the destination with source by computing contents

It computes by...

destination contents - source contents

The result is not stored but the FLAGS are affected

The OPERANDS of CMP may not both be Memory Locations

Destination may not be **CONSTANT**

CMP is just like SUB. However result is not stored in destination.

Signed Conditional Jumps



JG or JNLE	Jump if Greater than Jump if Not Less than or Equal to	ZF = 0 and SF = OF
JGE or JNL	Jump if Greater than or Equal to Jump if Not less than or Equal to	SF = OF
JL or JNGE	Jump if less than Jump if not greater than or equal	SF<>OF
JLE or JNG	Jump if less than or Equal Jump if not greater than	ZF = 1 or SF<> OF

Unsigned Conditional Jumps



JA or JNBE	Jump if Above Jump if Not Below or Equal to	ZF = 0 and CF = 0
JAE or JNB	Jump if Above or Equal to Jump if Not Below	CF = 0
JB or JNAE	Jump if Below Jump if not Above or Equal	CF = 1
JBE or JNA	Jump if Below or Equal Jump if Not Above	CF=1 or ZF = 1

Single-Flag Jumps



JE or JZ	<ul style="list-style-type: none"> • Jump if Equal • Jump if equal to Zero 	ZF = 1
JNE or JNZ	Jump if Not Equal Jump if Not Zero	ZF = 0
JC	Jump if Carry	CF = 1 CF = 0
JNC	Jump if no Carry	CF=0
JO	Jump if Overflow	CF=1 or ZF = 1
JNO	Jump if No Overflow	OF=1
JS	Jump if Sign Negative	SF = 1
JNS	Jump if Non-Negative Sign	SF =0
JP/JPE	Jump if Parity Even	PF=1
JNP/JPO	Jump if parity Odd	PF=1

Conditional Jumps Interpretation



Signed JUMPs correspond to an analogous unsigned JUMPs (i.e. JG is equivalent to JA)

Signed jump's operates on ZF, SF and OF

Unsigned JUMP's operates on ZF and CF

Using wrong kind of JUMP can lead to wrong results. For example: for AX= 7FFFh and BX= 8000h

CMP AX,BX

JA BELOW

Even though 7FFFh>8000h in a signed sense, the program does not jump to label BELOW. Because

In unsigned sense (JA) 7FFFh < 8000h

Working with Characters



To deal with ASCII character set, either Signed or Unsigned jumps may be used.

i.e. sign bit of a byte in a character is always zero.

However, while comparing extended ASCII characters (80h to FFh), UNSIGNED jumps should be used

JMP Instruction



JMP instruction causes an unconditional transfer of control.

JMP destination

Destination is usually a label in the same segment as the JMP itself. [ref: appendix - F]

To get around the range of restriction of a conditional jump, JMP can be used.

JMP Vs JNZ



TOP:

DEC CX

JNZ TOP

MOV AX,BX

TOP:

DEC CX

JNZ BOTTOM ; keep looping till

CX>0

JMP EXIT

BOTTOM:

JMP TOP

EXIT:

MOV AX,BX

High-Level Language Structures



Jump can be used to implement branches and loops

As the Jump is so primitive, it is difficult to code an algorithm with jumps without some guidelines.

The High-level languages (conditional IF-ELSE and While loops) can be simulated in assembly.



Branching Structures

Branching structures enable a program to take different paths, depending on conditions.

Here, We will look at three structures.

1. IF-THEN

2. IF-THEN-ELSE

3. CASE

IF-THEN

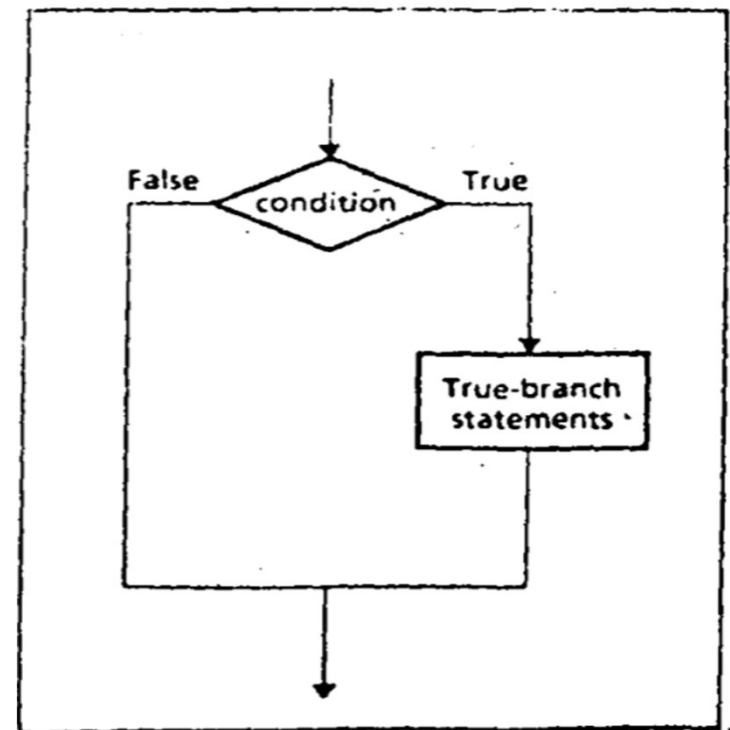


IF condition is true.

THEN

execute true-branch
statements

END_IF



A Pseudo Code , Algorithm and Code for IF-THEN



The condition is an expression that is either true or false.

If It is true, the true-branch statements are executed.

If It is false, nothing is done, and the program goes on to whatever follows.

Example: to Replace a number in AX by its absolute value...

```
IF AX < 0
THEN
    replace AX by -AX
END_IF
```

```
CMP AX, 0
JNL END_IF
NEG AX

END_IF:
```

IF-THEN-ELSE



IF condition is true

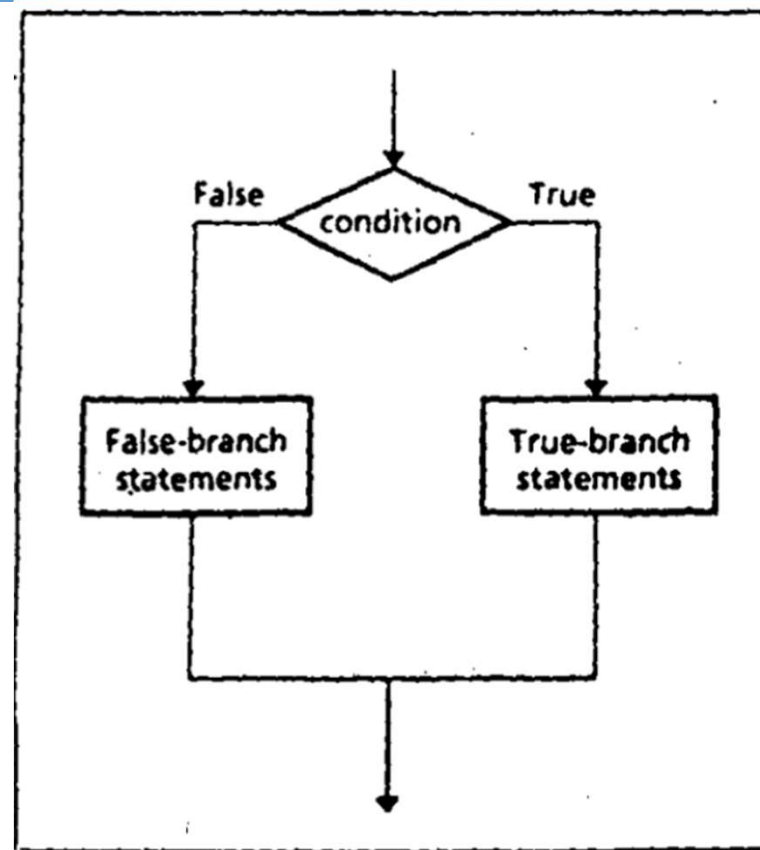
THEN

execute true-branch
statements

ELSE

execute false-branch
statements

END_IF



A Pseudo Code and algorithm and Code for IF-THEN-ELSE



The condition is an expression that is either true or false.

If It is true, the true-branch statements are executed.

If It is false then False-branch statements are executed.

Example: Suppose AL and BL contain extended ASCII characters. Display the one that comes first in the character sequence...

```
IF AL <= BL
    THEN
        Display the character in AL
    ELSE
        Display the character in BL
END IF
```

```
MOV AH,2
CMP AL,BL    ;AL<=BL ?
JNBE ELSE_
MOV DL,AL
JMP DISPLAY
ELSE_:
MOV DL,BL
DISPLAY:
INT 21h
```

CASE



A CASE is a **multi-way branch structure** that tests a register, variable, or expression for particular values or a range of values.

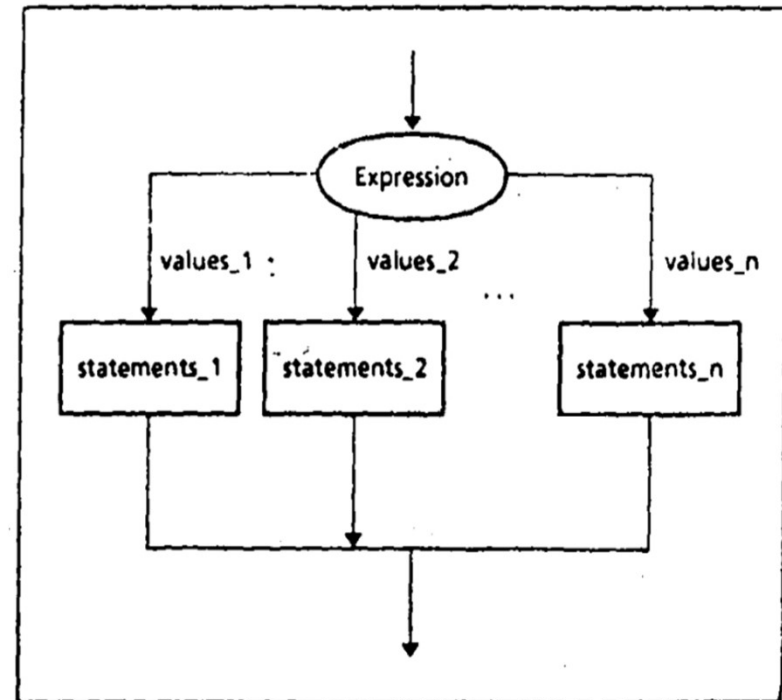
CASE Expression

Values_1: Statement_1

Values_2: Statement_2

...
Values_n: Statement_n

END_CASE



CASE



Example: If AX contains a negative number, put -1 in BX; if AX contains 0, put 0 in BX; and if AX contains a positive number, put 1 in BX.

CASE AX

<0 : put -1 in BX

=0 : put 0 in BX

>0 : put +1 in BX

END_CASE

CMP AX,0

JL NEGATIVE

JE ZERO

JG POSITIVE

NEGATIVE:

MOV BX,-1

JMP END_CASE

ZERO:

MOV BX,0

JMP END_CASE

POSITIVE:

MOV BX, 1

END_CASE:

Solve the Following



If AL contains 1 or 3, display "o"; if AL contains 2 or 4, display "e".

➤ CASE AL

1,3: display 'o'

2,4: display 'e'

END_CASE



References

- Assembly Language Programming and Organization of the IBM PC, Ytha Yu and Charles Marut, McGraw Hill, 1992. (ISBN: 0-07-072692-2).
- <https://www.slideshare.net/prodipghoshjoy/flow-control-instructions-60602372>



Books

- Assembly Language Programming and Organization of the IBM PC, Ytha Yu and Charles Marut, McGraw Hill, 1992. (ISBN: 0-07-072692-2).
- Essentials of Computer Organization and Architecture, (Third Edition), Linda Null and Julia Lobur
- W. Stallings, "Computer Organization and Architecture: Designing for performance", 6th Edition, Prentice Hall of India, 2003, ISBN 81 – 203 – 2962 – 7
- Computer Organization and Architecture by John P. Haynes.