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# THE MISADVENTURES OF X86

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April 19, 2020

## ABSTRACT

## 1 Introduction

## 2 History

In 1978, Intel released a 16-bit microprocessor chip called the Intel 8086. The 8086 project began in May 1976 as successor to the 8080 8-bit microprocessor and temporary solution to the iAPX 432 commercial failure. A new architecture was defined by Stephen P. Morse with the assistance of Bruce Ravenel. This architecture was created to support full 16-bit processing and maintain backwards compatibility with the 8080 and 8085 architectures. Making it possible to automatically convert source code with little to no user editing. In addition, new instructions were included such as microcoded multiply and divide, full support for signed integers, self-repeating operations, and base plus offset addressing. This architecture was named “x86” after Intel’s successor microprocessor chips ending with the number 86. Currently x86 is still used for low-level programming and a majority of mobile devices utilize the x86 architecture.[2]

## 3 Control Structures

When it comes to control structures x86 lets the user implement "jumps" this simple control structure is extremely volatile and allows the user to do both loops and conditional if/else statements. In x86 there are two types of jumps conditional and unconditional. Unconditional jumps consist of just a jump statement with a label address that it will always jump to by default. While conditional jumps will jump to the given address based off of a given condition that will return true or false, if false then the jump will not occur but if the conditional evaluates to true then the jump will occur. In order for the conditional statement to evaluate and run however, a comparison must be done that will return the required true/false flag. This comparison is in the form of CMP which is an Instruction that compares two values, it can take another register as arguments or it can take Integers to compare against each other. When this CMP instruction is computed, the evaluation is placed into the register EFLAGS.

X86’s jump instruction is expressed as JMP, such that jump takes in a “label” or address where it will jump to. An example of an unconditional Jump that goes to a given address will be shown here:

## Code Snippet 1 "Jump":

```

-----
section .data
    Msg1 db "This won't be printed.",10,0 ;Msg1 = "is won't be printed.\n"
    Msg1Len equ $ - Msg1 ;get length of Hello
    Msg2 db "This will be printed.",10,0 ;Hello = "This will be printed.\n"
    Msg2Len equ $ - Msg2 ;get length of Hello

section .text
    global _start

_start:
    mov eax,4 ;eax = 4
    mov ebx,1 ;ebx = 1
    mov ecx,Msg2 ;ecx = Msg2
    mov edx,Msg2Len ;edx = Msg2Len
    jmp skip ;jumps to skip
    mov ecx,Msg1 ;ecx = Msg1
    mov edx,Msg1Len ;edx = Msg1Len
skip:
    int 80h ;interrupt code 80h

    mov eax,1 ;system exit call
    mov ebx,0 ;argument returned 0
    int 0x80 ;interrupt code 0x80

```

As for conditional Jumps, in x86 there are a multitude of different conditional comparisons that can be used these will be presented below with a small snippet of code to demonstrate the comparison instruction CMP and the jump instruction that is conditional. Let it be noted that the comparison in CMP compares left argument to the right argument. This list is not exhaustive [2] (Control Flow Instructions):

1. je – Jump if equal

Ex.

cmp eax, 1 ; compare eax to 1  
je equalTo1 ; jump to address “equalTo1” if eax is equal to 1

2. jge – Jump if greater than or equal

Ex.

cmp eax, 10 ; compare eax to 10  
jge lessThan10 ; jump to “lessThan10” if eax is less than 10

3. jG – Jump if greater than

Ex.

cmp eax, 10 ; compare eax to 10  
jG lessThan10 ; jump to “lessThan10” if eax is less than 10

4. jns – Jump if not signed

Ex.

mov ecx, 10 ; ecx = -10  
jns skip ; if ecx is not a signed number jump to skip

5. js – Jump if signed

Ex.

mov ecx, -10 ; ecx = -10  
js skip ; if ecx is a signed number jump to skip

6. jl – Jump if less than

Ex.

cmp eax, 10 ; compare eax to 10  
jl lessThan10 ; jump to “lessThan10” if eax is less than 10

7. jle – Jump if less than or equal

Ex.

cmp eax, 10 ; compare eax to 10  
jle lessThan10 ; jump if eax is less than 10

8. jne – Jump if not equal

Ex.

cmp ecx, 100 ; ecx = 10  
jne skip ; if ecx != 100 jump to skip

In the scenario that any of these conditional statements is false, the program will simply fall through the code and not execute the jump, thus executing the instruction directly below the jump/cmp instructions. These different instructions that show how to compare two items and execute a specific as a result of the comparison can be related to if/else if/else statements that are in languages like c and java etc. These comparisons will go to the jump if the “if statement” is true and will skip the jump if the comparison is false. In x86 the jump instruction is limited to which address space can be reached, the maximum jump distance from the current address is a 32-bit size, and this applies to both 64- and 32-bit versions of x86 programs.

Rather than have separate control structures for if conditional statements and for loops / while loops, in x86 you can create for and while loops using the conditional jump statements and addresses. An example is shown here in this small program that computes the factorial of a number that is stored in the register ebx.

Code Snippet 1 "Jump":

```
-----
section .data
    Msg1 db "This won't be printed.",10,0    ;Msg1 = "is won't be printed.\n"
    Msg1Len equ $ - Msg1                    ;get length of Hello
    Msg2 db "This will be printed.",10,0     ;Hello = "This will be printed.\n"
    Msg2Len equ $ - Msg2                    ;get length of Hello

section .text
    global _start

_start:
    mov eax,4        ;eax = 4
    mov ebx,1        ;ebx = 1
    mov ecx,Msg2     ;ecx = Msg2
    mov edx,Msg2Len   ;edx = Msg2Len
    jmp skip         ;jumps to skip
    mov ecx,Msg1     ;ecx = Msg1
    mov edx,Msg1Len   ;edx = Msg1Len
skip:
    int 80h          ;interrupt code 80h

    mov eax,1        ;system exit call
    mov ebx,0        ;argument returned 0
    int 0x80         ;interrupt code 0x80
```

This program essentially creates a while loop that will continually break down a number subtracting one from it every loop and multiplying the new difference, with the previous product until the factorial of the originally stored number in ebx is found. This loop will continually repeat itself while ebx is greater than 1, notice the snippet “jg label” which will check to see if ebx is greater than one and will jump to the established address space that is labelled as “label:”. Once ebx is 1 then the loop will end, and the jump will not execute thus ending the program and outputting the factorial. This demonstrates how you can make both a while loop to end on a given condition or how you can use a register that stores a specific number to run the loop a specific number of times like a for loop in java or c.

## 4 Data

## 5 Subprograms

## 6 Summary

## References

- [1] x86 Assembly Guide. <https://www.cs.virginia.edu/~evans/cs216/guides/x86.html>. Accessed: 2020-04-13.
- [2] Leo J Scanlon. *8086/8088/80286 assembly language*. New York, N.Y. : Brady Books : Distributed by Prentice, 1988.