CSE316: Microprocessors and Microcontrollers Sessional

Assembly Programming Lecture 2

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Introduction

- FLAGS register (ch. 5)¹
- Branching (ch. 6)
- Bit manipulation (ch. 7)

¹ "Assembly Language Programming and Organization of the IBM PC" by Ytha Yu and Charles Marut

- A 16-bit register
- Six bits are used as status flags
- Three bits are used as control flags

status flags reflect the result of a computation

control flags enable/disable certain operations of the processor



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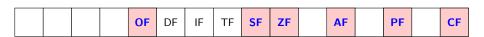
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FLAGS Register: Status Flags

Γ												
			ΩF	DE	l IF	TF	SE	7F	ΔF	PF	ĺ	CF
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FLAGS Register: Status Flags

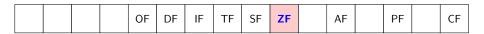


FLAGS Register: Status Flags (Cntd.)

- A single flag might be affected by a number of operations
- One operation might affect zero or more flags

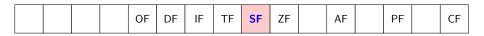
Instruction	Affected Flags
MOV/XCHG	none
ADD/SUB	all
INC/DEC	all except CF
NEG	all ²

FLAGS Register: Zero Flag



- **ZF** is set if the result of certain operations is zero
- SUB AX,AX

FLAGS Register: Sign Flag



• **SF** is set if the result of certain operations contains one in MSB

FLAGS Register: Parity Flag

				OF	DF	IF	TF	SF	ZF		AF		PF		CF	
--	--	--	--	----	----	----	----	----	----	--	----	--	----	--	----	--

- The parity flag denotes even parity
- If the *lower byte* result contains even number of 1's, PF is set

FLAGS Register: Auxiliary Carry Flag



- AF comes into play only during BCD arithmetic
- To the interested readers: take a peek at Ch. 18
- Set when there is a carry out from lower to upper nibble

- The range of numbers a computer can represent is limited
- An 8-bit register can represent:
 - unsigned numbers from 0 to $2^8 1$ (0 to 255)
 - signed numbers from -2^7 to $2^7 1$ (-128 to 127)
- If the result falls outside the range, overflow occurs
- A truncated result is obtained that is incorrect



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The Concept of Overflow (Cntd.)

- Overflow can be signed or unsigned
- They are represented by the Overflow and the Carry flag respectively

Overflow Type	OF	CF
None	0	0
Unsigned Only	0	1
Signed Only	1	0
Both	1	1

$$OF = 0$$
, $CF = 0$

	signed	unsigned
AL=02H	+2	2
BL=27H	+37	37
add	+39	39

0000	0010
+0010	0101
0010	0111

$$\mathsf{OF} = \mathsf{0}, \, \mathsf{CF} = \mathsf{1}$$

	signed	unsigned
AL=FFH	-1	255
BL=01H	+1	1
add	0	256

1111	1111
+0000	0001
10000	0000



$$OF = 1$$
, $CF = 0$

	signed	unsigned
AL=7FH	+127	127
BL=7FH	+127	127
add	+254	254

0111	1111
+0111	1111
1111	1110



$$OF = 1$$
, $CF = 1$

	signed	unsigned
AL=80H	-128	128
BL=80H	-128	128
add	-256	256

1000	0000
+1000	0000
10000	0000

End of FLAGS

Branching

- Execute different instructions depending on conditions
- Execute a section of code repeatedly
- Branching can be conditional or unconditional
- The FLAGS register is extensively used for conditional instructions

Example Case: If

If AX>BX, store AX in DX



- CMP dest, src
- Performs subtraction (dest src)
- The result is not stored (i.e. dest is not changed)
- FLAGS register affected

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If AX>BX, store AX in DX

CMP AX,BX

JG STORE

JMP END_IF

STORE:

MOV DX,AX

END_IF:

CMP AX,BX

JLE END_IF

ЛОV DX,АХ

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STORE:

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STORE:

MOV DX,AX

END_IF:

CMP AX,BX

JLE END_IF

MOV DX,AX

If AX>BX, then SUB AX,BX; else ADD AX,BX

CMP AX,BX

JLE ELSE_

SUB AX,BX

JMP END_IF

ELSE_:

ADD AX,BX



If AX>BX, then SUB AX,BX; else ADD AX,BX

CMP AX,BX

JLE ELSE_

SUB AX,BX

JMP END_IF

ELSE_:

ADD AX,BX



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CMP AX,BX

JLE ELSE_

SUB AX,BX

JMP END_IF

 ELSE_{-} :

ADD AX,BX



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CMP AX,BX

JLE ELSE_

SUB AX,BX

JMP END_IF

 ELSE_{-} :

ADD AX,BX



If AX>BX, then SUB AX,BX; else ADD AX,BX

CMP AX,BX

JLE ELSE_

SUB AX,BX

JMP END_IF

ELSE_:

ADD AX,BX



$$AX>BX: CX=1; AX==BX: CX=0; AX$$

CMP AX,BX

JG POSITIVE

JE ZERO

JL NEGATIVE

DOCITIVE

MOV CX.1

JMP END CASE

ZERO:

MOV CX,0

JMP END_CASE

NEGATIVE:

MOV CX,-1

$$AX>BX: CX=1; AX==BX: CX=0; AX$$

CMP AX,BX

JG POSITIVE

JE ZERO

JL NEGATIVE

DOCITIVE.

MOV CX,1

JMP END CASE

ZERO:

MOV CX,0

JMP END_CASE

NEGATIVE:

MOV CX,-1

$$AX>BX: CX=1; AX==BX: CX=0; AX$$

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POSITIVE:

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JMP END_CASE

ZERO:

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NEGATIVE:

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CMP AX,BX

JG POSITIVE

JE ZERO

JL NEGATIVE

POSITIVE:

MOV CX,1

JMP END CASE

ZERO:

MOV CX,0

JMP END_CASE

NEGATIVE

MOV CX,-1

AX>BX: CX=1; AX==BX: CX=0; AX<BX: CX=-1

ZERO:

CMP AX,BX

JG POSITIVE MOV CX.0

JE ZERO JMP END CASE

JL NEGATIVE NEGATIVE:

POSITIVE: MOV CX.-1

MOV CX.1

JMP END CASE

If CL represents an uppercase letter, then put 1 in CL; else put 0 in CL

If CL represents an uppercase letter, then put 1 in CL; else put 0 in CL

CMP CL,'A'

JNGE ELSE

CMP CL,'Z'

JNLE ELSE_

MOV CL,1

JMP END_IF

ELSE_:

MOV CL,0



If CL represents an uppercase letter, then put 1 in CL; else put 0 in CL

CMP CL,'A'

JNGE ELSE_

CMP CL,'Z'

JNLE ELSE_

MOV CL,1

JMP END_IF

ELSE_:

MOV CL.0



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CMP CL,'A'

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If CL represents an uppercase letter, then put 1 in CL; else put 0 in CL

```
CMP CL.'A'
JNGE ELSE_
CMP CL,'Z'
JNLE ELSE
MOV CL,1
JMP END IF
FLSE:
MOV CL,0
END_IF
```

If CL represents 'y' or 'Y', then put 1 in CL; else put 0 in CL



If CL represents 'y' or 'Y', then put 1 in CL; else put 0 in CL

CMP CL,'y' JE THEN

CMP CL,'Y'

JE THEN

MOV CL,0

JMP END_IF

THEN:

MOV CL,1



If CL represents 'y' or 'Y', then put 1 in CL; else put 0 in CL

CMP CL,'y'

JE THEN

CMP CL,'Y'

JE THEN

MOV CL,0

JMP END_IF

THEN:

MOV CL,1



If CL represents 'y' or 'Y', then put 1 in CL; else put 0 in CL

CMP CL,'y'

JE THEN

CMP CL,'Y'

JE THEN
MOV CL,0

THEN:

MOV CL,1



If CL represents 'y' or 'Y', then put 1 in CL; else put 0 in CL

CMP CL,'y'
JE THEN
CMP CL,'Y'
JE THEN
MOV CL,0

THEN:

MOV CL,1



If CL represents 'y' or 'Y', then put 1 in CL; else put 0 in CL

CMP CL,'y'
JE THEN
CMP CL,'Y'
JE THEN
MOV CL,0

JMP END_IF

THEN: MOV CL,1



If CL represents 'y' or 'Y', then put 1 in CL; else put 0 in CL

CMP CL,'y' JE THEN CMP CL,'Y' JE THEN MOV CL,0 JMP END_IF THEN: MOV CL,1 **END IF**

The LOOP Instruction

- Performs instructions N number of times
- The value *N* is stored in **CX**
- Takes the form: LOOP label
- Decrements CX at each invocation, jumps to label if CX not 0

Print the full alphabet in capital letters

MOV AH,2 MOV CX,26 MOV DL,65 TOP: INT 21H INC DL

Print the full alphabet in capital letters

MOV AH,2

MOV CX,26

MOV DL.65

TOP:

INT 2

INC DL



Print the full alphabet in capital letters

MOV AH,2

MOV CX,26

MOV DL,65

TOP:

INT 21H

INC DL



Print the full alphabet in capital letters

MOV AH,2

MOV CX,26

MOV DL,65

TOP:

INT 21F

INC DL



Print the full alphabet in capital letters

MOV AH,2

MOV CX,26

MOV DL,65

TOP:

INT 21H

INC DL



Print the full alphabet in capital letters

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MOV CX,26

MOV DL,65

TOP:

INT 21H

INC DL



Print the full alphabet in capital letters

MOV AH,2

MOV CX,26

MOV DL,65

TOP:

INT 21H

INC DL



The LOOP Instruction: Caveat

- The LOOP instruction will execute at least once
- This causes a problem when CX initially contains 0
- After decrementing the content becomes FFFH (65535)
- So the instructions are executed 65535 more times
- The instruction JCXZ can be used to take care of this

Example Case: While

Count number of characters in input line

Example Case: While

Count number of characters in input line

MOV DX,0

MOV AH,1

NT 21H

WHILE_:

CMP AL,0DH

JE END_WHILE

NC DX

INT 21H

JMP WHILE_

END WHIE

Count number of characters in input line

MOV DX,0

MOV AH,1

N I 21H

WHILE_:

CMP AL,0DH

JE END_WHILE

NC DX

INT 21H

JMP WHILE

Count number of characters in input line

MOV DX,0

MOV AH,1

INT 21H

WHILE ::

CMP AL,0DH

JE END_WHILE

INC DX

INT 21H

JMP WHILE.

ENIB WILLE

Count number of characters in input line

MOV DX,0

MOV AH,1

INT 21H

WHILE_:

CMP AL,0DH

JE END_WHILE

INC DX

INT 21H

JMP WHILE



Count number of characters in input line

MOV DX,0

MOV AH,1

INT 21H

WHILE ::

CMP AL,0DH

JE END_WHILE

NC DX

INT 21H

JMP WHILE_



Count number of characters in input line

MOV DX,0

MOV AH,1

INT 21H

WHILE ::

CMP AL,0DH

JE END_WHILE

INC DX

INT 21H

JMP WHILE_



Count number of characters in input line

MOV DX,0

MOV AH,1

INT 21H

WHILE ::

CMP AL,0DH

JE END_WHILE

INC DX

INT 21H

JMP WHILE_

Count number of characters in input line

MOV DX,0

MOV AH,1

INT 21H

WHILE_:

CMP AL,0DH

JE END_WHILE

INC DX

INT 21H

JMP WHILE_



Take input until 'N' is pressed

MOV AH,1 TOP: INT 21H CMP AL,'N JNE TOP

Take input until 'N' is pressed

MOV AH,1

TOP:

INT 21H

CMP AL,'N

JNE TOP



Take input until 'N' is pressed

MOV AH,1

TOP:

INT 21H

CMP AL,'N'

JNE TOP



Take input until 'N' is pressed

MOV AH,1

TOP:

INT 21H

CMP AL,'N'

JNE TOP

Take input until 'N' is pressed

MOV AH,1 TOP: INT 21H CMP AL,'N' JNE TOP

Properties of Jump Instructions

- Jump instructions do not affect the flags
- Conditional jumps cannot jump:
 - more than 126 bytes before the jump instruction
 - more than 127 bytes after the jump instruction
- This restriction can be bypassed through an unconditional jump

Properties of Jump Instructions (Cntd.)

- There are three types of conditional jumps:
 - signed jump
 - unsigned jump
 - single flag jump
- See Table 6.1 for details

Signed VS Unsigned Jump

- Every signed jump has a corresponding unsigned jump
- For example JG and JA
- Suppose AL=7FH and BL=80H
- In signed representation AL>BL
- However, in unsigned representation AL<BL



End of Branching



AND, OR, XOR

Effect on flags:

- SF, ZF, PF reflect the result
- AF undefined
- CF,OF=0

Common usage:

- AND is used to clear specific bits
- OR is used to set specific bits
- XOR is used to toggle specific bits

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NOT

- Single operand instruction
- Performs 1's complement
- Does not affect the status flags

TEST

- Performs AND of the two operands
- However, does not store the result
- Affects the status flags the same way AND does
- Helps to find out whether a specific bit is set or not

Shift Instructions: SHL/SAL

- SHL dest,1 or SHL dest,CL
- Every bit shifts left, MSB shifted to CF, 0 shifted into LSB
- Effect on flags:
 - SF, PF, ZF reflect the result
 - AF is undefined
 - CF = last bit shifted out
 - OF = 1 if result changes sign on last shift

Shift Instructions: SHR/SAR

- SHR dest,1 or SHR dest,CL
- Every bit shifts right, LSB shifted to CF, 0 shifted into MSB
- Effect on flags is similar to that of SHR
- SAR retains the MSB

Rotate Instructions: ROL

- ROL dest,1 or ROL dest,CL
- Every bit shifts left, MSB shifted to LSB and to CF
- All rotate instructions affect the flags in similar manner:
 - SF, PF, ZF reflect the result
 - AF is undefined
 - CF = last bit shifted out
 - \bullet OF = 1 if result changes sign on the last rotation

Rotate Instructions: ROR

- ROR dest,1 or ROR dest,CL
- Every bit shifts right, LSB shifted to MSB and to CF

Rotate Instructions: RCR/RCL

- RCR dest,1 or RCR dest,CL
- Similar to ROR/ROL, but with CF in the loop

- Read the chapters thoroughly (you may exclude section 5.4)
- Try out all the example codes in the book
- Solve all the exercises
- EMU8086 allows you to examine the values of registers
- The emulator also has a single step execution mode
- Use these to understand how different operations affect the flags

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Questions?

