

Computer Structure and Language

The 8086/8088 Assembly Language

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1

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Computer Structure & Language, Lecture#6: String and decimal instructions

2

8086/88 has 7 types of instructions:

1. Data Transfer Instructions
2. Arithmetic Instructions
3. Bit Manipulation Instructions
4. String Instructions
5. Program Execution Transfer Instructions
6. Processor Control Instructions
7. Interrupt Instructions

2

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The 8086/88's String Processing Instructions:

- Load String Byte/Word to AL/AX: LODS**

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

Possible Use Cases: LODS label, LODSB, LODSW

1010110 w $AL \leftarrow (M_{(SI)}); \text{ if } DF=1 \text{ then } SI \leftarrow (SI)-1 \text{ else } SI \leftarrow (SI)+1; \text{ if } w=0$
 $AX \leftarrow (M_{(SI)}); \text{ if } DF=1 \text{ then } SI \leftarrow (SI)-2 \text{ else } SI \leftarrow (SI)+2; \text{ if } w=1$
- Store String Byte/Word from AL/AX: STOS**

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

Possible Use Cases: STOS label, STOSB, STOSW

1010101 w $M_{(DI)} \leftarrow (AL); \text{ if } DF=1 \text{ then } DI \leftarrow (DI)-1 \text{ else } DI \leftarrow (DI)+1; \text{ if } w=0$
 $M_{(DI)} \leftarrow (AX); \text{ if } DF=1 \text{ then } DI \leftarrow (DI)-2 \text{ else } DI \leftarrow (DI)+2; \text{ if } w=1$
- Scan String Byte/Word: SCAS**

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

Possible Use Cases: SCAS label, SCASB, SCASW

1010111 w

Realize $(AL) - (M_{(DI)})$ and update Flags; if $DF=1$ then $DI \leftarrow (DI)-1$ else $DI \leftarrow (DI)+1$; if $w=0$
Realize $(AX) - (M_{(DI)})$ and update Flags; if $DF=1$ then $DI \leftarrow (DI)-2$ else $DI \leftarrow (DI)+2$; if $w=1$

** In all string instructions, the segment register used with SI is DS and segment register used with DI is ES.*

3

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The 8086/88's String Processing Instructions:

- Move String Byte/Word: MOVS**

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

Possible Use Cases: MOVS labels, MOVSB, MOVSW

1010010 w $M_{(DI)} \leftarrow (M_{(SI)})_{\text{byte}}; \text{ if } DF=1 \text{ then } \{DI \leftarrow (DI)-1; SI \leftarrow (SI)-1\} \text{ if } w=0$
 $\text{else } \{DI \leftarrow (DI)+1; SI \leftarrow (SI)+1\}$

$M_{(DI)} \leftarrow (M_{(SI)})_{\text{word}}; \text{ if } DF=1 \text{ then } \{DI \leftarrow (DI)-2; SI \leftarrow (SI)-2\} \text{ if } w=1$
 $\text{else } \{DI \leftarrow (DI)+2; SI \leftarrow (SI)+2\}$
- Compare String Byte/Word: CMPS**

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

Possible Use Cases: CMPS labels, CMPSB, CMPSW

1010011 w

Realize $(M_{(SI)})_{\text{byte}} - (M_{(DI)})_{\text{byte}}$ and update Flags; if $w=0$
if $DF=1$ then $\{DI \leftarrow (DI)-1; SI \leftarrow (SI)-1\}$ else $\{DI \leftarrow (DI)+1; SI \leftarrow (SI)+1\}$

Realize $(M_{(SI)})_{\text{word}} - (M_{(DI)})_{\text{word}}$ and update Flags; if $w=1$
if $DF=1$ then $\{DI \leftarrow (DI)-2; SI \leftarrow (SI)-2\}$ else $\{DI \leftarrow (DI)+2; SI \leftarrow (SI)+2\}$

** In all string instructions, the segment register used with SI is DS and segment register used with DI is ES.*

4

The 8086/88's String Processing Instructions:

- Repeat Prefix: REP**

Possible Use Cases: REP MOVS, REP LODS, REP STOS

11110011

1. If (CX)=0 then exit;
2. Perform string instruction;
3. $CX \leftarrow (CX)-1$; Goto 1;

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

- Repeat on Equal/Zero Prefix: REPE/REPZ**

Possible Use Cases: REPZ/REPE SCAS, REPZ/REPE CMPS

11110011

1. If (CX)=0 or ZF=0 then exit;
2. Perform string instruction;
3. $CX \leftarrow (CX)-1$; Goto 1;

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

- Repeat on Not Equal/Not Zero Prefix: REPNE/REPNZ**

Possible Use Cases: REPNZ/REPNE SCAS, REPNZ/REPNE CMPS

11110010

1. If (CX)=0 or ZF=1 then exit;
2. Perform string instruction;
3. $CX \leftarrow (CX)-1$; Goto 1;

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

5

The 8086/88's Decimal Computing Instructions:

Decimal numbers can be shown in two formats:

- **Packed Decimal:** Each byte shows two decimal digits
- **ASCII (unpacked) Decimal:** Each byte shows one decimal digit

It is the programmers duty to keep the sign and define decimal numbers using **db** directive.

Machine has few limited instructions to support decimal calculations. They include **AAA, AAS, AAM, AAD, DAA, DAS**.

All instructions work on one byte decimal numbers

- 2 digits for packed decimal, and
- one digit for ASCII numbers).

6

The 8086/88's Decimal Computing Instructions:

ASCII (unpacked) Decimal Computing Instructions:

- ASCII Adjust for Addition: AAA**

00110111

if $(AL) \wedge 0Fh > 9$ or $AF=1$ then $AL \leftarrow (AL) + 6$; $AH \leftarrow (AH) + 1$;
 $AF \leftarrow 1$; $CF \leftarrow AF$;
 $AL \leftarrow (AL) \wedge 0Fh$;

*AAA is used after actual binary addition.

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

- ASCII Adjust for Subtraction: AAS**

00111111

if $(AL) \wedge 0Fh > 9$ or $AF=1$ then $AL \leftarrow (AL) - 6$; $AH \leftarrow (AH) - 1$;
 $AF \leftarrow 1$; $CF \leftarrow AF$;
 $AL \leftarrow (AL) \wedge 0Fh$;

*AAS is used after actual binary subtraction.

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

7

The 8086/88's Decimal Computing Instructions:

ASCII (unpacked) Decimal Computing Instructions:

- ASCII Adjust for Multiplication: AAM**

11010100

00001010

$AH \leftarrow (AL)/10$; $AL \leftarrow \text{Remainder}$;

*AAM is used after actual binary multiplication.

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

- ASCII Adjust for Division: AAD**

11010101

00001010

$AL \leftarrow (AH)*10 + (AL)$; $AH \leftarrow 0$;

*AAD is used before actual binary division.

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

8

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The 8086/88's Decimal Computing Instructions:

BCD (packed) Decimal Computing Instructions:

• Decimal Adjust for Addition: DAA

00100111

if (AL) ^ 0Fh > 9 or AF=1 then AL ← (AL) + 6; AF ← 1;

if (AL) > 9Fh or CF=1 then AL ← (AL) + 60h; CF ← 1;

*DAA is used after actual binary Addition.

• Decimal Adjust for Subtraction: DAS

00101111

if (AL) ^ 0Fh > 9 or AF=1 then AL ← (AL) - 6; AF ← 1;

if (AL) > 9Fh or CF=1 then AL ← (AL) - 60h; CF ← 1;

*DAS is used after actual binary Subtraction.

OFDFIFTFSSFZFAFPFCF

U- - - X X X X X

OFDFIFTFSSFZFAFPFCF

U- - - X X X X X

9

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End of Slides

10

5