

Introduction to 8086 Assembly

Lecture 7

Multiplication and Division

Multiplication commands: mul and imul



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mul source (source: register/memory)



Unsigned Integer Multiplication (mul)

- `mul src` (`src: register/memory`)
 - `src: 8 bits` `ax <- al * src`
 - `src: 16 bits` `dx:ax <- ax * src`
 - `src: 32 bits` `edx:eax <- eax * src`
 - `src: 64 bits` `rdx:rax <- rax * src` (x64 only)

Unsigned Integer multiplication (mul)



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mul src8



8 bit

mul src16



16 bit

mul src32



32 bit

mul src64



64 bit (x64 only)

Example

- `mul bl`
- `mul bx`
- `mul ebx`
- `mul rbx (x64 only)`

Example



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```
11:  db  0xFF, 0x1A, 0x11, 0xE2  
      db  0x2A, 0x82, 0x1F, 0x74  
  
mul  [11]
```

Example



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```
11:  db  0xFF, 0x1A, 0x11, 0xE2
      db  0x2A, 0x82, 0x1F, 0x74
```

~~mul [11]~~

mul byte	[11]	; 8 bit	$AX = AL * [I1]$
mul word	[11]	; 16 bit	$DX:AX = AX * [I1]$
mul dword	[11]	; 32 bit	$EDX:EAX = EAX * [I1]$
mul qword	[11]	; 64 bit	$RDX:RAX = RAX * [I1]$



Signed Integer Multiplication (imul)

- `imul src` (`src: register/memory`)
 - `src: 8 bits` `ax <- al * src`
 - `src: 16 bits` `dx:ax <- ax * src`
 - `src: 32 bits` `edx:eax <- eax * src`
 - `src: 64 bits` `rdx:rax <- rax * src` (`x64 only`)

Signed Integer multiplication (mul)



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`imul src8`



8 bit

`imul src16`



16 bit

`imul src32`



32 bit

`imul src64`



64 bit (x64 only)

Question



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Why not have **add** and **iadd** just like
mul and **imul**?



Other forms of imul

- `imul src`
- `imul dest, src`
- `imul dest, src1, src2`

`dest = dest * src`

`dest = src1 * src2`



Other forms of imul

- **imul** src **src:** reg/mem
- **imul** dest, src **dest:** reg **src:** reg/mem/immed
- **imul** dest, src1, src2 **dest:** reg **src1:** reg/mem **src2:** immed

Practice: Factorial

Write a program reading an integer and printing its factorial

- assume that the answer fits in 32 bits

Practice: Factorial



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fact.asm

```
call read_int
mov ecx, eax

mov eax, 1
loop1:
mul ecx

loop loop1

call print_int
call print_nl
```

Practice: Factorial

Write a program reading an integer and printing its factorial

- print an error message if the answer is out of range

Practice: Factorial



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```
segment .data
```

fact2.asm

```
msg:      db "out of range!", 10, 0
```

```
segment .text
```

```
:
```

```
call read_int
```

```
mov ecx, eax
```

```
mov eax, 1
```

```
l1:
```

```
mul ecx
```

```
cmp edx, 0
```

```
jne errlbl
```

```
loop l1
```

```
call print_int
```

```
call print_nl
```

```
jmp endl
```

fact2.asm (cont.)

```
errlbl:
```

```
mov eax, msg
```

```
call print_string
```

```
endl:
```


Division

- `div source` (source: register/memory)
- `idiv source` (source: register/memory)



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Integer division (div, idiv)

- `div src8,`
- `idiv src8` (`src8: 8 bits`)
 - `al` \leftarrow `ax` / `src8` (`quotient`)
 - `ah` \leftarrow `ax` % `src8` (`remainder`)

Example:

- `div bh`
- `div byte [11]`



Integer division (div, idiv)

- `div src16,`
- `idiv src16` (`src16: 16 bits`)
 - `ax` \leftarrow `dx:ax` / `src16` (`quotient`)
 - `dx` \leftarrow `dx:ax` % `src16` (`remainder`)

Example:

- `div cx`
- `div word [a]`



Integer division (div, idiv)

- `div src32,`
- `idiv src32` (`src32: 32 bits`)
 - `eax` \leftarrow `edx:eax` / `src32` (`quotient`)
 - `edx` \leftarrow `edx:eax` % `src32` (`remainder`)

Example:

- `div esi`
- `div dword [num1]`



Integer division (div, idiv)

- `div src64,`
- `idiv src64` (`src64`: 64 bits, x64 only)
 - `rax` \leftarrow `rdx:rax` / `src64` (quotient)
 - `rdx` \leftarrow `rdx:rax` % `src64` (remainder)

Example:

- `div rdi`
- `div qword [sum]`

Integer Division



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div src8

remainder	quotient		AX			
AH	AL	=	AH	AL	/	src8

8 bit

div src16

remainder	quotient					
DX	AX	=	DX	AX	/	src16

16 bit

div src32

remainder	quotient					
EDX	EAX	=	EDX	EAX	/	src32

32 bit

div src64

remainder	quotient					
RDX	RAX	=	RDX	RAX	/	src64

64 bit (x64 only)

Further reading



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- https://www.tutorialspoint.com/assembly_programming/assembly_arithmetic_instructions.htm
- https://en.wikibooks.org/wiki/X86_Assembly/Arithmetic
- https://www.csie.ntu.edu.tw/~acpang/course/asm_2004/slides/chapt_07_PartIISolve.pdf

Errors can happen in division



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```
mov eax, 0
mov edx, 1 ; edx:eax=2^32

mov ecx, 1
div ecx
```


Errors can happen in division



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```
mov eax, 0
mov edx, 1 ; edx:eax=2^32

mov ecx, 1
div ecx
```

```
b.nasihatkon@kntu:lecture7$ ./run.sh divoverflow
./run.sh: line 5: 23877 Floating point exception(core dumped) ./$1
```

Usually dividend and divisor are of the same size!

Unsigned:

```
mov edx, 0  
div esi
```



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Usually dividend and divisor are of the same size!

Unsigned:

```
mov edx, 0  
div esi
```

Signed:

```
CDQ  
idiv ebx
```

Remember: Extending bit size - signed



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- `AX ← AL` **CBW** (convert Byte to Word)
 - `EAX ← AX` **CWDE** (convert Word to double word extended)
 - `RAX ← EAX` **CDQE** (convert Double to Quad extended, **x64**)
-
- `DX:AX ← AX` **CWD** (convert Word to Double word)
 - `EDX:EAX ← EAX` **CDQ** (convert Double word to Quad word)
 - `RDX:RAX ← RAX` **CQO** (convert Quad word to Oct Word, **x64**)

Practice: Prime Numbers



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Write a program reading an integer and printing if it is prime

- assume that input is larger than 1

Practice: Prime Numbers



segment .data

prime.asm

```
prime_msg:    db "Prime!", 10, 0
notprime_msg: db "Not prime!", 10, 0
```

segment .text

:

```
call read_int
mov ebx, eax
```

```
mov ecx, 2
```

startloop:

```
cmp ecx, ebx
jge endloop
```

```
mov eax, ebx
mov edx, 0
div ecx
```

```
cmp edx, 0
je notprime_lbl
```

```
inc ecx
jmp startloop
```

endloop:

```
mov eax, prime_msg
call print_string
jmp endl
```

notprime_lbl:

```
mov eax, notprime_msg
call print_string
```

endl:

prime.asm (cont.)

Code on the right also correct?



startloop:

```
    cmp ecx, ebx
    jge endloop

    mov eax, ebx
    mov edx, 0
    div ecx
    cmp edx, 0
    je notprime_lbl

    inc ecx
    jmp startloop
```

endloop:

```
    mov eax, prime_msg
    call print_string
    jmp endl
```

notprime_lbl:

```
    mov eax, notprime_msg
    call print_string
```

endl:

startloop:

```
    cmp ecx, eax
    jge endloop

    mov eax, ebx
    mov edx, 0
    div ecx
    cmp edx, 0
    je notprime_lbl

    inc ecx
    jmp startloop
```

endloop:

```
    mov eax, prime_msg
    call print_string
    jmp endl
```

notprime_lbl:

```
    mov eax, notprime_msg
    call print_string
```

endl: