Introduction to 8086 Assembly

Lecture 7

Multiplication and Division

Multiplication commands: mul and imul

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)

mul src8	AH	AL	=	AL	*	src8	8 bit
mul src16	DX	AX	=	AX	*	src16	16 bit
mul src32	EDX	EAX	=	EAX	*	src32	32 bit
mul src64	RDX	RAX	=	RAX	*	src64	64 bit (x64 only)

Example

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

Example

```
l1:  db  0xFF, 0x1A, 0x11, 0xE2
     db  0x2A, 0x82, 0x1F, 0x74

mul [l1]
```

Example

```
l1:   db   0xFF, 0x1A, 0x11, 0xE2
      db   0x2A, 0x82, 0x1F, 0x74
```

~~mul [l1]~~

```
mul byte  [l1]     ;  8 bit      AX = AL * [l1]
mul word  [l1]     ;  16 bit     DX:AX = AX * [l1]
mul dword [l1]     ;  32 bit     EDX:EAX = EAX * [l1]
mul qword [l1]     ;  64 bit     RDX:RAX = RAX * [l1]
```

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)

imul src8	AH	AL	=	AL	*	src8	8 bit
imul src16	DX	AX	=	AX	*	src16	16 bit
imul src32	EDX	EAX	=	EAX	*	src32	32 bit
imul src64	RDX	RAX	=	RAX	*	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	dest = dest * src
● imul dest, src1, src2	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

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Write a program reading an integer and printing its factorial

- assume that the answer fits in 32 bits

Practice: Factorial

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

fact2.asm

```
segment .data

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
```

fact2.asm (cont.)

```
    call print_int
    call print_nl
    jmp  endl

errlbl:
    mov  eax, msg
    call print_string

endl:
```

Division

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

Integer division (div, idiv)

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

Example:

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

Integer division (div, idiv)

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

Example:

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

Integer division (div, idiv)

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

Example:

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

Integer division (div, idiv)

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

Example:

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

Integer Division

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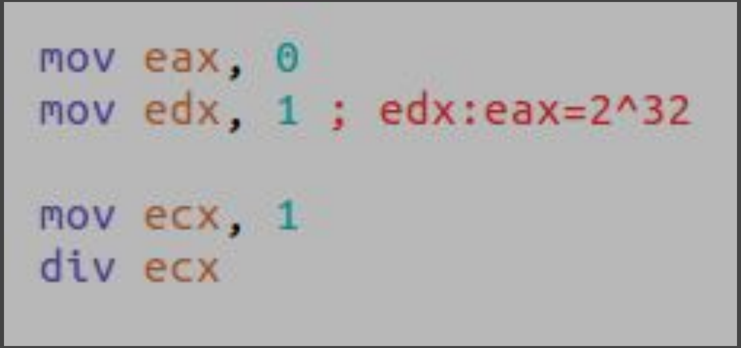
	remainder	quotient		AX				
div src8	AH	AL	=	AH	AL	/	src8	8 bit
	remainder	quotient						
div src16	DX	AX	=	DX	AX	/	src16	16 bit
	remainder	quotient						
div src32	EDX	EAX	=	EDX	EAX	/	src32	32 bit
	remainder	quotient						
div src64	RDX	RAX	=	RDX	RAX	/	src64	64 bit (x64 only)

Further reading

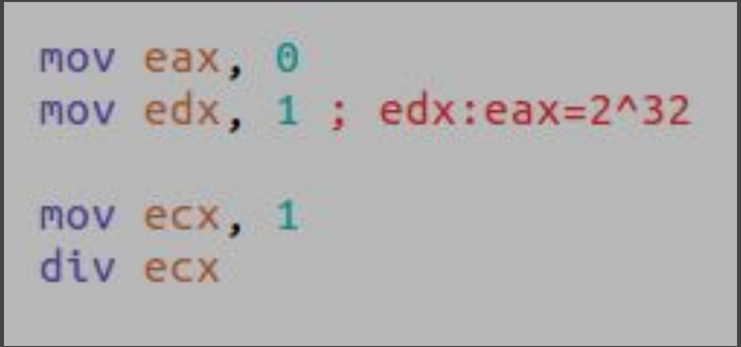
- https://www.tutorialspoint.com/assembly_programming/assembly_arithmetic_instructions.htm
- https://en.wikibooks.org/wiki/X86_Assembly/Arithmetic
- https://www.csie.ntu.edu.tw/~acpang/course/asm_2004/slides/chapt_07_PartIISolve.pdf

Errors can happen in division

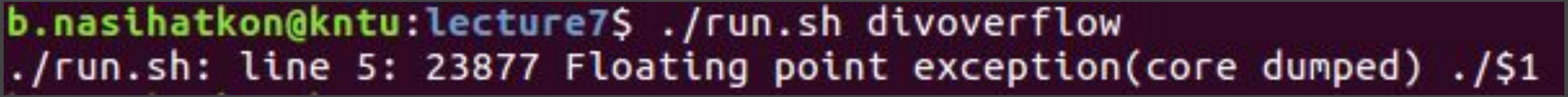


```
mov eax, 0
mov edx, 1 ; edx:eax=2^32

mov ecx, 1
div ecx
```

Errors can happen in division



```
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
```

Usually dividend and divisor are of the same size!

Unsigned:

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

Signed:

```
CDQ
idiv  ebx
```

Remember: Extending bit size - signed

- 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

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

- assume that input is larger than 1

Practice: Prime Numbers

prime.asm

```
segment .data

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

segment .text
            :
      call read_int
      mov ebx, eax

      mov ecx, 2
```

prime.asm (cont.)

```
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:
```

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:
```