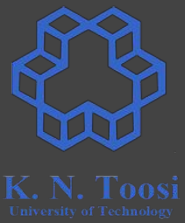
Introduction to 8086 Assembly

Lecture 6

Working with memory

Why using memory?



- Registers are limited in number and size
- Program data
- Program code
- etc.

The data segment


```
segment .data

    dd 1234
    dw 13
    db -123
```

The data segment


```
segment .data

    dd 1234
    dw 13
    db -123
```

But how to access data?

How to access data? Labels!


```
segment .data

l1:  dd 1234
     dw 13
     db -123
```

How to access data?

memory1.asm

```
segment .data
l1:     dd 1234

segment .text
        global  asm_main
asm_main:
        enter   0,0
        pusha

        mov eax, l1
        call print_int
        call print_nl

        mov eax, [l1]
        call print_int
        call print_nl
```

Reading data from memory

K. N. Toosi
University of Technology

```
segment .data

l1:     dd 1234

segment .text
        global  asm_main
asm_main:
        enter   0,0
        pusha

        mov eax, l1
        call print_int
        call print_nl

        mov eax, [l1]
        call print_int
        call print_nl
```

```
b.nasihatkon@kntu:lecture6$ ./run.sh memory1
134520872
1234
```

Data labels vs. Code labels

memory2.asm

```
segment .data
l1:     dd 1234

segment .text
        global  asm_main
asm_main:
        enter   0,0
        pusha

        mov eax, asm_main
        call print_int
        call print_nl

        mov eax, [asm_main]
        call print_int
        call print_nl
```

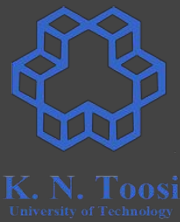
Data labels vs. Code labels

memory2.asm

```
segment .data
l1:     dd 1234

segment .text
        global  asm_main
asm_main:
        enter   0,0
        pusha

        mov eax, asm_main
        call print_int
        call print_nl

        mov eax, [asm_main]
        call print_int
        call print_nl
```

```
b.nasihatkon@kntu:lecture6$ ./run.sh memory2
134513872
200
```

Putting data in memory




```
11:     db   123
12:     dw   1000
13:     db   11010b
14:     db   12o
16:     dd   1A92h
17:     dd   0x1A92
18:     db   'A'
19:     db   "B"
```

Putting data in memory


```
11:     db   123
12:     dw   1000
13:     db   11010b
14:     db   12o
16:     dd   1A92h
17:     dd   0x1A92
18:     db   'A'
19:     db   "B"
```

data size (not data type!)

Putting data in memory


```
11:     db   123
12:     dw   1000
13:     db   11010b
14:     db   12o
16:     dd   1A92h
17:     dd   0x1A92
18:     db   'A'
19:     db   "B"
```

data size (not data type!)

db	1 byte
dw	2 bytes
dd	4 bytes
dq	8 bytes
dt	10 bytes

Putting data in memory


```
l1:     db   123
l2:     dw   1000
l3:     db   11010b
l4:     db   12o
l6:     dd   1A92h
l7:     dd   0x1A92
l8:     db   'A'
l9:     db   "B"
```

data size

```
mov  eax, l1
call print_int
call print_nl

mov  eax, l2
call print_int
call print_nl

mov  eax, l3
call print_int
call print_nl

mov  al, [l8]
call print_char
call print_nl
```

Putting data in memory


```
11:     db   123
12:     dw   1000
13:     db   11010b
14:     db   12o
16:     dd   1A92h
17:     dd   0x1A92
18:     db   'A'
19:     db   "B"
```

data size

```
mov  eax, 11
call print_int
call print_nl

mov  eax, 12
call print_int
call print_nl

mov  eax, 13
call print_int
call print_nl

mov  al, [18]
call print_char
call print_nl
```

```
b.nasihatkon@kntu
134520872
134520873
134520875
A
```

Definitions in the book

K. N. Toosi
University of Technology

```
L1      db      0           ; byte labeled L1 with initial value 0
L2      dw      1000        ; word labeled L2 with initial value 1000
L3      db      110101b     ; byte initialized to binary 110101 (53 in decimal)
L4      db      12h         ; byte initialized to hex 12 (18 in decimal)
L5      db      17o         ; byte initialized to octal 17 (15 in decimal)
L6      dd      1A92h       ; double word initialized to hex 1A92
L7      resb    1           ; 1 uninitialized byte
L8      db      "A"         ; byte initialized to ASCII code for A (65)
```

Carter, *PC Assembly Language*, 2007.

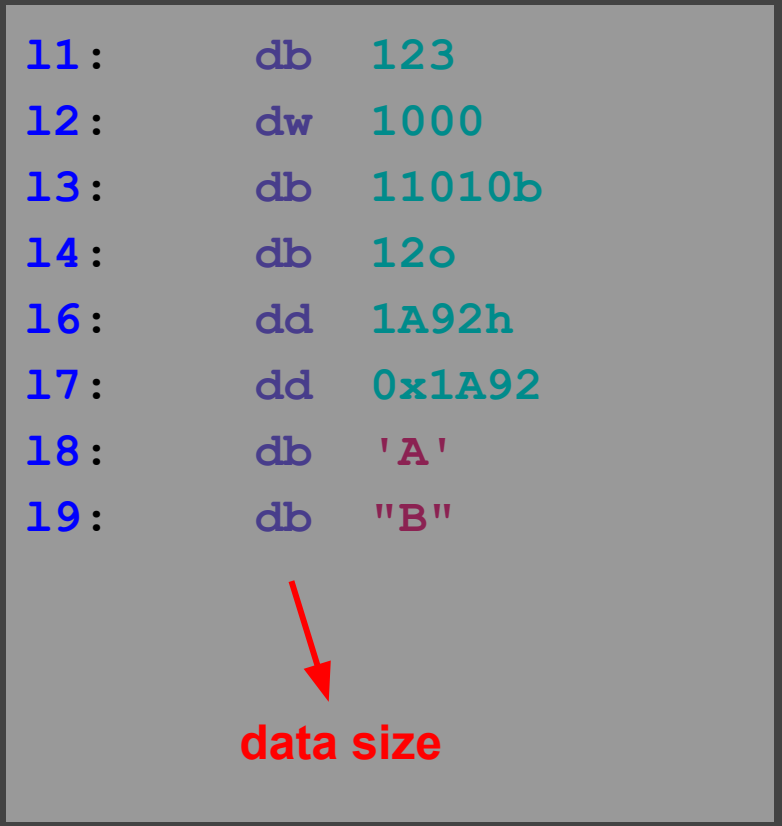
Putting data in memory


```
11:     db   123
12:     dw   1000
13:     db   11010b
14:     db   12o
16:     dd   1A92h
17:     dd   0x1A92
18:     db   'A'
19:     db   "B"
```

data size

Where are the variables?

Putting data in memory



High-level languages (like C)

- Variables

Low-level language (assembly)

- Labels (Symbols, Addresses)

K. N. Toosi
University of Technology

Putting data in memory


```
segment .data

l1:     dd 11, 12, 13, 14, 15, 16
```

```
mov eax, [l1]
call print_int
call print_nl

mov eax, [l1+1]
call print_int
call print_nl

mov eax, [l1+2]
call print_int
call print_nl

mov eax, [l1+3]
call print_int
call print_nl


mov eax, [l1+4]
call print_int
call print_nl
```

Putting data in memory


```
segment .data

l1:     dd 11, 12, 13, 14, 15, 16
```

```
b.nasihatkon@kntu:lecture6$ ./run.sh memory4
11
201326592
786432
3072
12
```

```
mov eax, [l1]
call print_int
call print_nl

mov eax, [l1+1]
call print_int
call print_nl

mov eax, [l1+2]
call print_int
call print_nl

mov eax, [l1+3]
call print_int
call print_nl


mov eax, [l1+4]
call print_int
call print_nl
```

Putting data in memory


```
segment .data

l1:     dd 11, 12, 13, 14, 15, 16

l2:     dd 8, 8, 8, 8, 8, 8, 8, 8, 8

l3:     times 9   dd 8

l4:     resd  9

l5:     resw  18

l6:     resb  36
```

Argument types


```
segment .data

l1:     dd 11, 12, 13, 14, 15, 16

segment .text

mov eax, [l1]
mov [l1+4], ebx

mov eax, ebx

mov eax, l1
mov eax, 123
```

memory

register

immediate (constant)

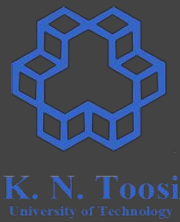
Invalid mem,mem assembly commands


```
segment .data
l1:     dd 11, 12, 13, 14
l2:     dd 100

segment .text

mov [l1], [l2]
add [l1], [l2]
sub [l1], [l2]
adc [l1], [l2]
sbb [l1], [l2]
cmp [l1], [l2]
and [l1], [l2]
or  [l1], [l2]
xor [l1], [l2]
```

Invalid mem,mem assembly commands


```
segment .data
11:     dd 11, 12, 13, 14
12:     dd 100

segment .text

mov [11], [12]
add [11], [12]
sub [11], [12]
adc [11], [12]
sbb [11], [12]
cmp [11], [12]
and [11], [12]
or  [11], [12]
xor [11], [12]
```

Operation size

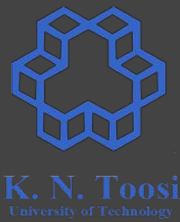



```
segment .data
l1:     dd 11, 13, 14
l2:     dd 100

segment .text

mov [l1], eax
add  eax, [l2]


sub  eax, 44
mov [l1], 44
```

Operation size

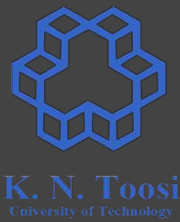

```
segment .data
l1:     dd 11, 13, 14
l2:     dd 100

segment .text

mov [l1], eax
add  eax, [l2]


sub  eax, 44
mov [l1], 44
mov dword [l1], 44
mov word [l1], 44
mov byte [l1], 44
```

Assembly command formats



- List of x86 instructions
  - http://www.felixcloutier.com/x86/
  - https://c9x.me/x86/
  - https://zsmith.co/intel.html

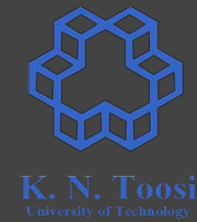
Storing multibyte data




```
segment .data
a:     dd    16753508

segment .text
          :
          :

        mov eax, 0

        mov  al, [a]
        call print_int
        call print_nl
```

endianness1.asm

Storing multibyte data

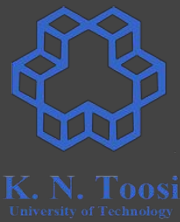



```
segment .data
a:     dd    16753508

segment .text
          :
          :

        mov eax, 0

        mov  al, [a]
        call print_int
        call print_nl
```

endianness1.asm

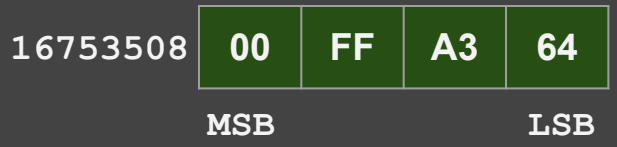
16753508	00	FF	A3	64

Storing multibyte data




```
segment .data
a:     dd    16753508

segment .text
          :
          :

        mov eax, 0

        mov  al, [a]
        call print_int
        call print_nl
```

endianness1.asm



Storing multibyte data


```
segment .data
a:     dd    16753508

segment .text
          :
          :

        mov eax, 0

        mov  al, [a]
        call print_int
        call print_nl
```

endianness1.asm

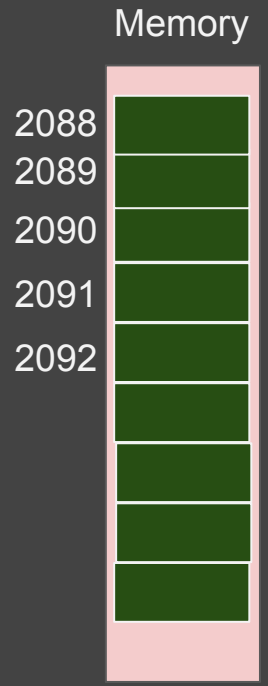
16753508	00	FF	A3	64
	MSB			LSB
decimal	0	255	163	100

Storing multibyte data


```
segment .data
a:     dd    16753508

segment .text
          :
          :

        mov eax, 0

        mov  al, [a]
        call print_int
        call print_nl
```

endianness1.asm

16753508	00	FF	A3	64
	MSB			LSB
decimal	0	255	163	100

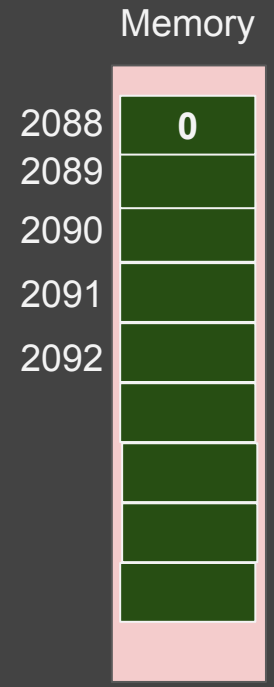


Storing multibyte data


```
segment .data
a:     dd    16753508

segment .text
          :
          :

        mov eax, 0

        mov  al, [a]
        call print_int
        call print_nl
```

endianness1.asm

16753508	00	FF	A3	64
	MSB			LSB
decimal	0	255	163	100

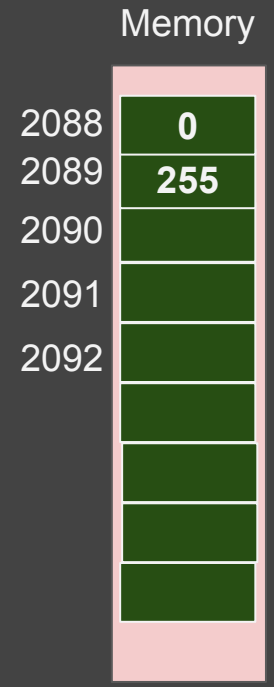


Storing multibyte data


```
segment .data
a:     dd    16753508

segment .text
          :
          :

        mov eax, 0

        mov  al, [a]
        call print_int
        call print_nl
```

endianness1.asm

16753508	00	FF	A3	64
	MSB			LSB
decimal	0	255	163	100

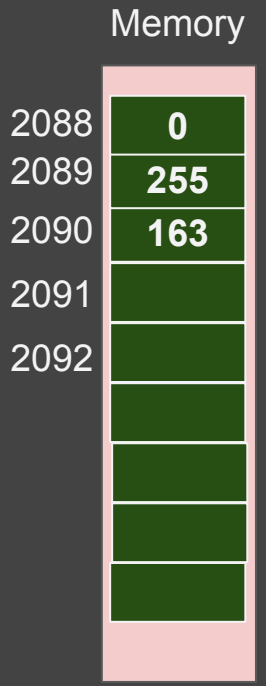


Storing multibyte data

```
segment .data
a:     dd    16753508

segment .text
          :
          :

        mov eax, 0

        mov  al, [a]
        call print_int
        call print_nl
```

endianness1.asm

16753508	00	FF	A3	64
	MSB			LSB
decimal	0	255	163	100



K. N. Toosi
University of Technology

Storing multibyte data


```
segment .data
a:     dd    16753508

segment .text
          :
          :

        mov eax, 0

        mov  al, [a]
        call print_int
        call print_nl
```

endianness1.asm

16753508	00	FF	A3	64
	MSB			LSB
decimal	0	255	163	100

Memory

2088	0
2089	255
2090	163
2091	100
2092	

Storing multibyte data


```
segment .data
a:      dd    16753508

segment .text
          :
          :

        mov eax, 0

        mov  al, [a]
        call print_int
        call print_nl
```

endianness1.asm

16753508	00	FF	A3	64
	MSB			LSB
decimal	0	255	163	100

Memory

2088	0
2089	255
2090	163
2091	100
2092	

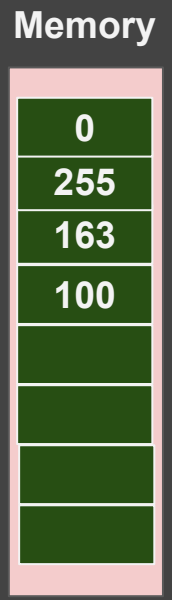
```
b.nasihatkon@kntu:lecture6$ ./run.sh endianness1
100
```

Endianness

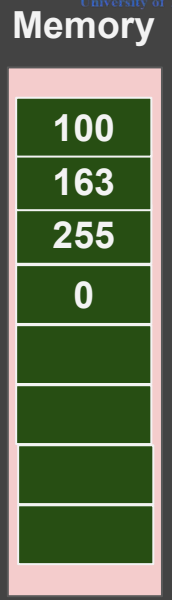

```
segment .data
a:     dd    16753508
segment .text
      :
  mov eax, 0

  mov  al, [a]
  call print_int
  call print_nl

  mov  al, [a+1]
  call print_int
  call print_nl

  mov  al, [a+2]
  call print_int
  call print_nl

  mov  al, [a+3]
  call print_int
  call print_nl
```

endianness2.asm

16753508	00	FF	A3	64
	MSB			LSB
decimal	0	255	163	100



Big Endian



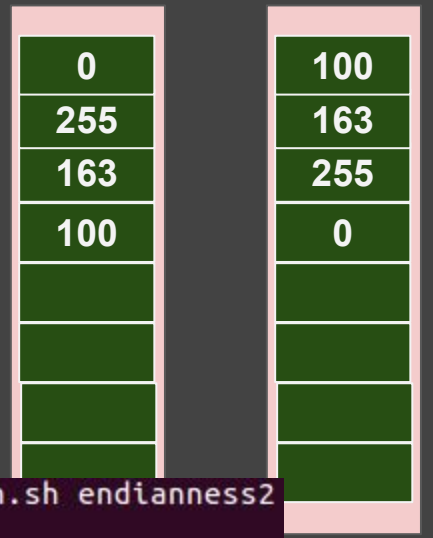
Little Endian (e.g. x86)

Endianness

```
segment .data
a:    dd   16753508
segment .text
      :
  mov eax, 0

  mov  al, [a]
  call print_int
  call print_nl

  mov  al, [a+1]
  call print_int
  call print_nl

  mov  al, [a+2]
  call print_int
  call print_nl

  mov  al, [a+3]
  call print_int
  call print_nl
```

endianness2.asm

16753508	00	FF	A3	64
	MSB			LSB
decimal	0	255	163	100




```
b.nasihatkon@kntu:lecture6$ ./run.sh endianness2
100
163
255
0
```

Little Endian (e.g. x86)

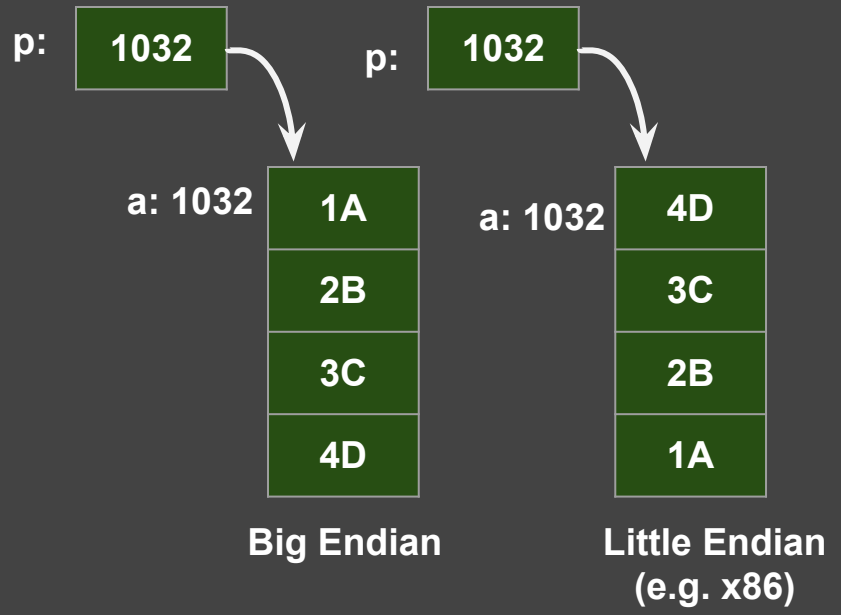
K. N. Toosi University of Technology

Checking endianness in C

K. N. Toosi
University of Technology

```c
unsigned int a = 0x1A2B3C4D;
printf("%X\n", a);

unsigned char *p = (unsigned char *)(&a);
printf("%X\n", *p);
printf("%X\n", *(p+1));
printf("%X\n", *(p+2));
printf("%X\n", *(p+3));
```

test_endianness.c

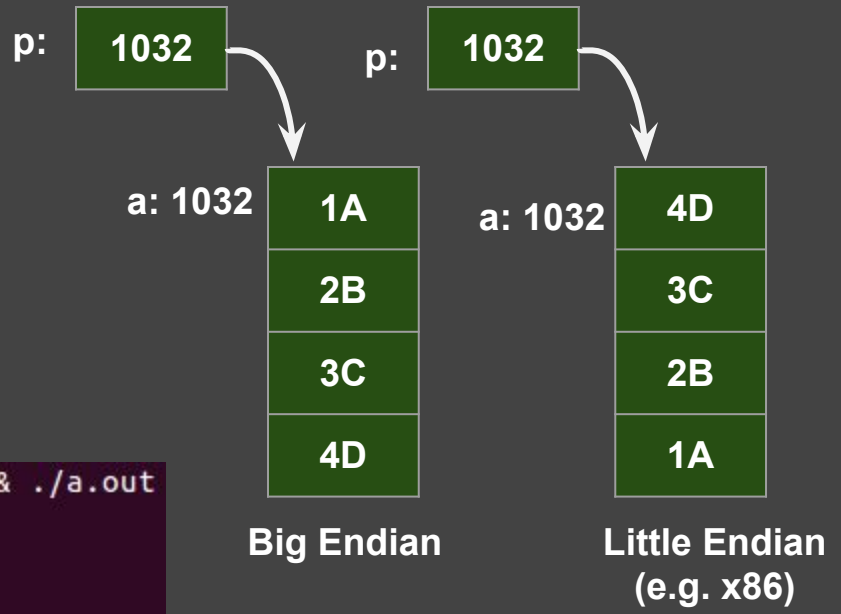


Checking endianness in C

K. N. Toosi
University of Technology

```c
unsigned int a = 0x1A2B3C4D;
printf("%X\n", a);

unsigned char *p = (unsigned char *)(&a);
printf("%X\n", *p);
printf("%X\n", *(p+1));
printf("%X\n", *(p+2));
printf("%X\n", *(p+3));
```

```
b.nasihatkon@kntu:lecture6$ gcc test_endianness.c && ./a.out
1A2B3C4D
4D
3C
2B
1A
```



Change endianness


```
xchg  ah, al ; 16 bit

bswap eax    ; 32 bit

bswap rax    ; 64 bit (x64 only)
```