Buffers & Direct Storage

Part 5

1

Buffers

Creating your own space

2

Buffers

- A *buffer* is any allocated block of memory that contains data
- This can hold anything:
  - text
  - image
  - file
  - etc.…

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Buffers

- There are several assembly directives which will allocate space
- We have covered a few of them, but there are many – all with a specific purpose

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A few directives that create space

Directive	What it does
`.ascii`	Allocate enough space to store an ASCII string
`.quad`	Allocate 8-byte blocks with initial value(s)
`.byte`	Allocate byte(s) with initial value(s)
`.space`	Allocate any ***size*** of empty bytes (with initial values).

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Labels are addresses

- Labels are used to keep track of memory locations
- They are stored, by the assembler, in a table
- Whenever a label is used in the program, the assembler substitutes the address

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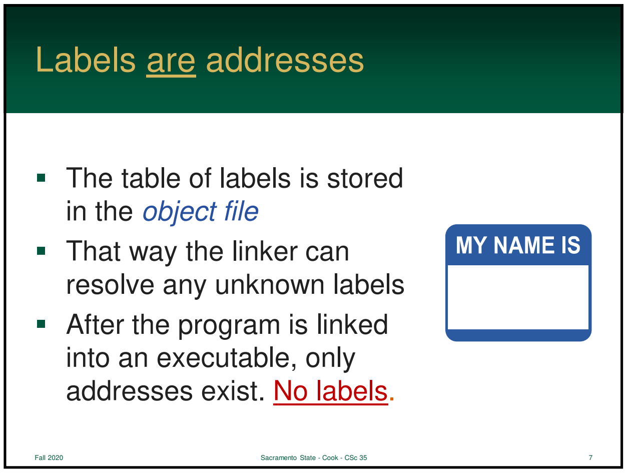

Labels are addresses

- The table of labels is stored in the *object file*
- That way the linker can resolve any unknown labels
- After the program is linked into an executable, only addresses exist. No labels.

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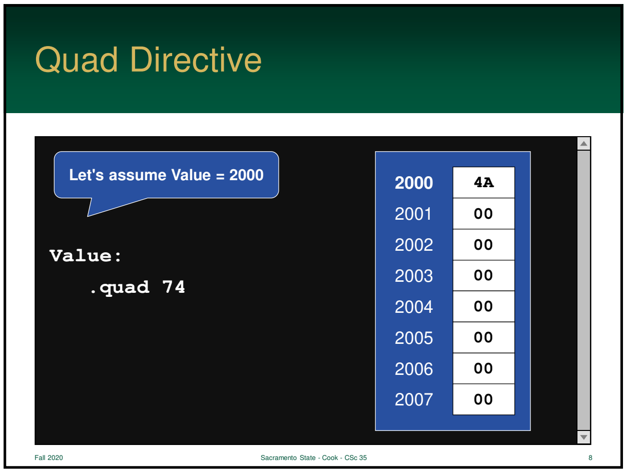

Quad Directive

Let's assume Value = 2000

```
Value:
    .quad 74
```

2000	4A
2001	00
2002	00
2003	00
2004	00
2005	00
2006	00
2007	00

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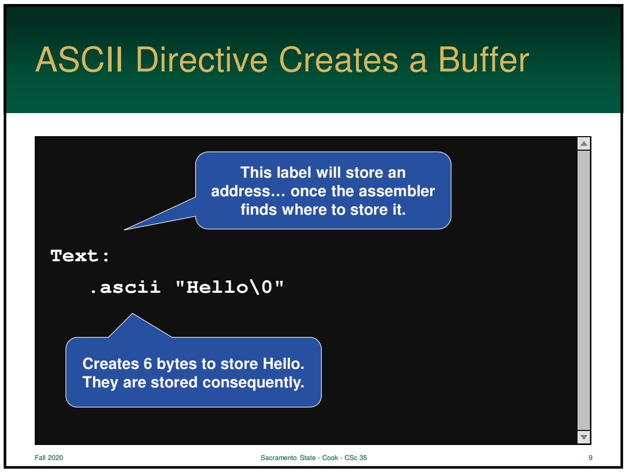

ASCII Directive Creates a Buffer

This label will store an address… once the assembler finds where to store it.

```
Text:
    .ascii "Hello\0"
```

Creates 6 bytes to store Hello. They are stored consequently.

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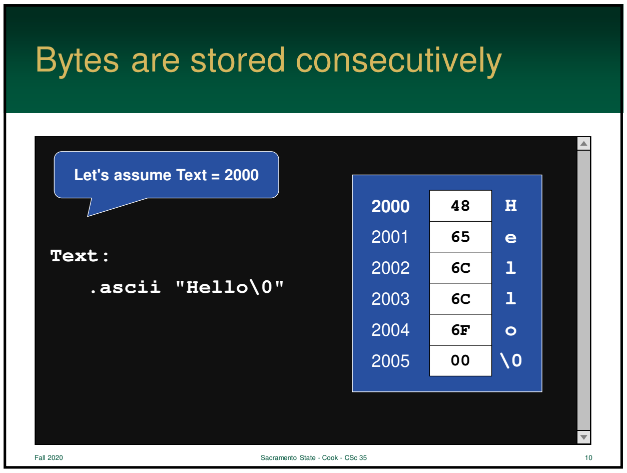

Bytes are stored consecutively

Let's assume Text = 2000

```
Text:
    .ascii "Hello\0"
```

2000	48	H
2001	65	e
2002	6C	l
2003	6C	l
2004	6F	o
2005	00	\0

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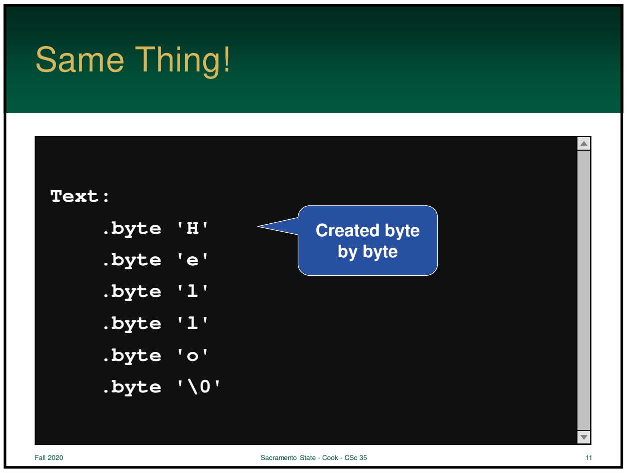

Same Thing!

```
Text:
     .byte 'H'
     .byte 'e'
     .byte 'l'
     .byte 'l'
     .byte 'o'
     .byte '\0'
```

Created byte by byte

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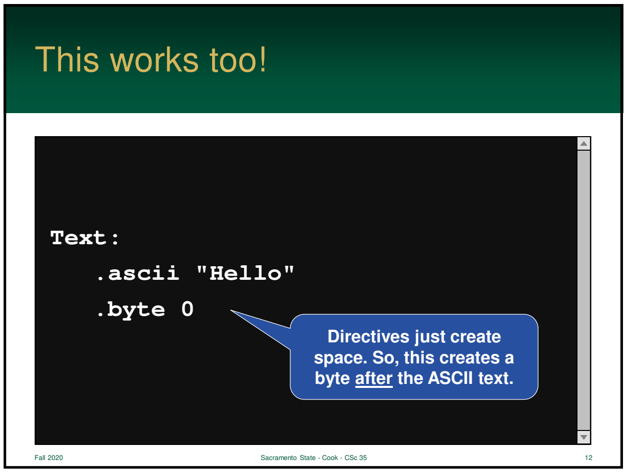

This works too!

```
Text:
    .ascii "Hello"
    .byte 0
```

Directives just create space. So, this creates a byte after the ASCII text.

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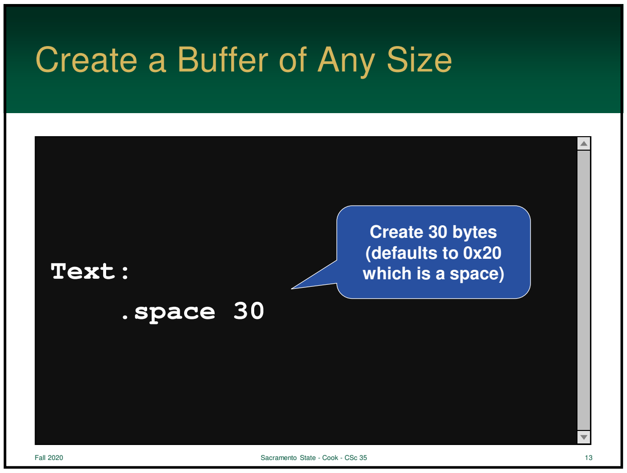

Create a Buffer of Any Size

```
Text:
    .space 30
```

Create 30 bytes (defaults to 0x20 which is a space)

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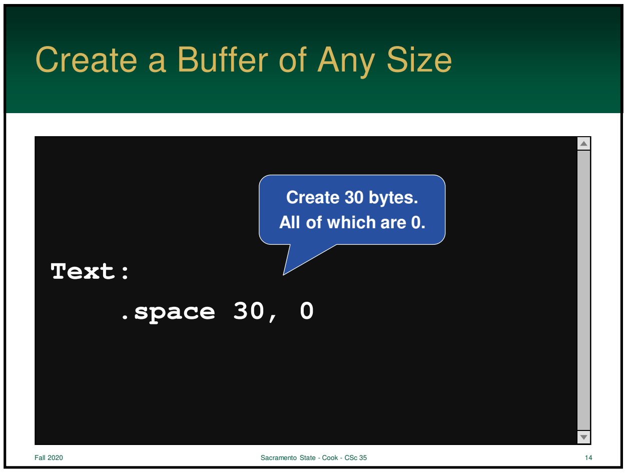

Create a Buffer of Any Size

```
Text:
    .space 30, 0
```

Create 30 bytes. All of which are 0.

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Direct Addressing

Using memory… finally

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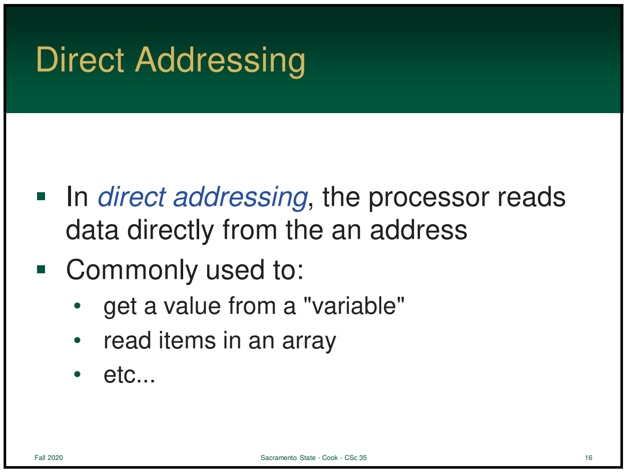

Direct Addressing

- In *direct addressing*, the processor reads data directly from the an address
- Commonly used to:
  - get a value from a "variable"
  - read items in an array
  - etc...

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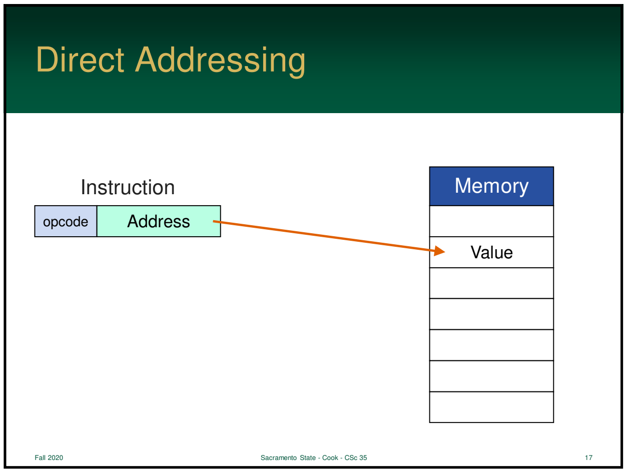

Direct Addressing

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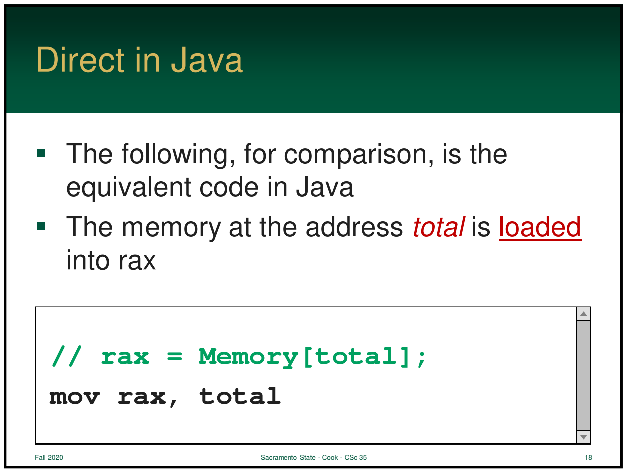

Direct in Java

- The following, for comparison, is the equivalent code in Java
- The memory at the address *total* is loaded into rax

```
// rax = Memory[total];
mov rax, total
```

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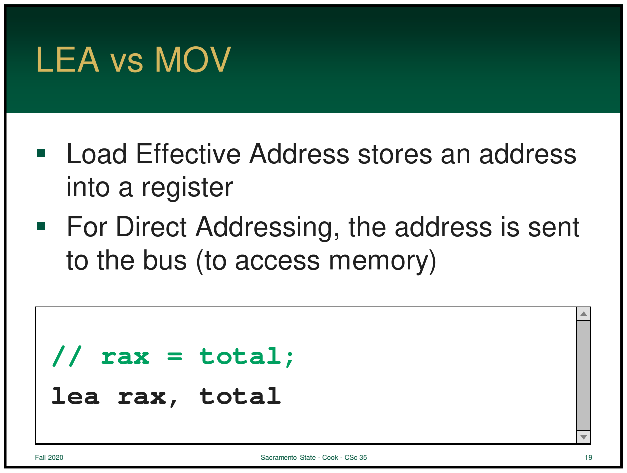

LEA vs MOV

- Load Effective Address stores an address into a register
- For Direct Addressing, the address is sent to the bus (to access memory)

```
// rax = total;
lea rax, total
```

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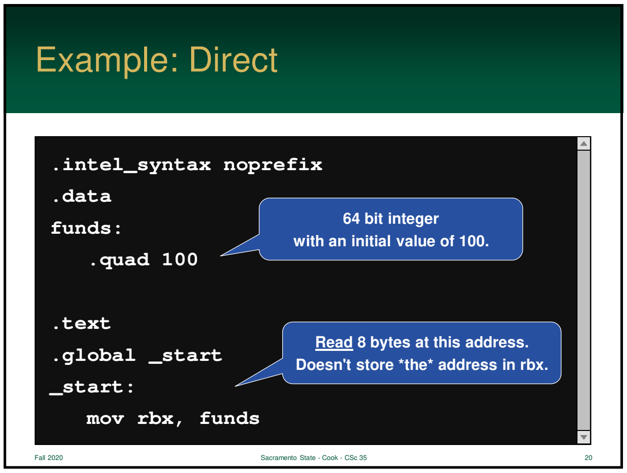

Example: Direct

```
.intel_syntax noprefix
.data
funds:
    .quad 100

.text
.global _start
_start:
    mov rbx, funds
```

64 bit integer with an initial value of 100.

Read 8 bytes at this address. Doesn't store *the* address in rbx.

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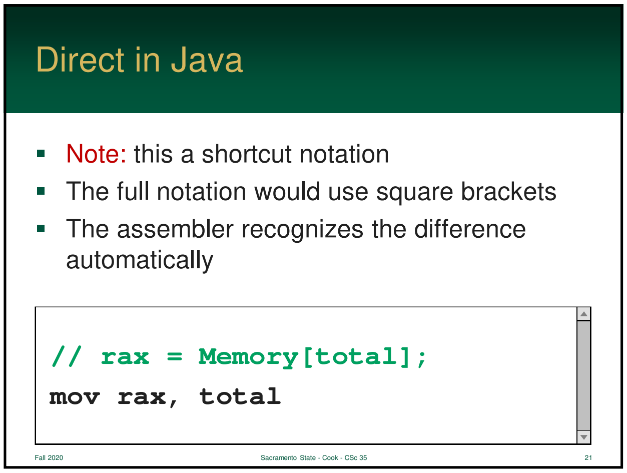

Direct in Java

- Note: this a shortcut notation
- The full notation would use square brackets
- The assembler recognizes the difference automatically

```
// rax = Memory[total];
mov rax, total
```

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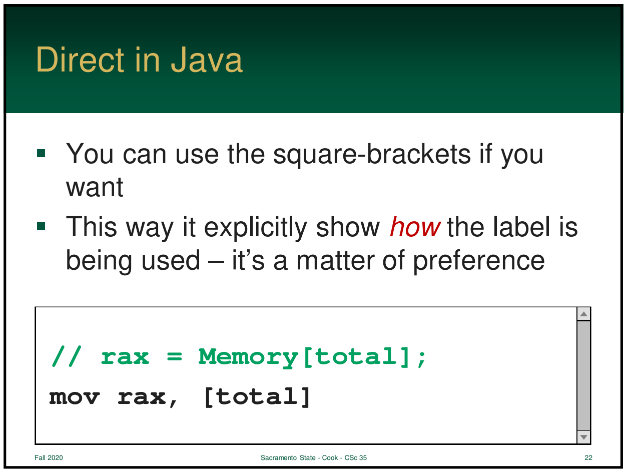

Direct in Java

- You can use the square-brackets if you want
- This way it explicitly show *how* the label is being used – it's a matter of preference

```
// rax = Memory[total];
mov rax, [total]
```

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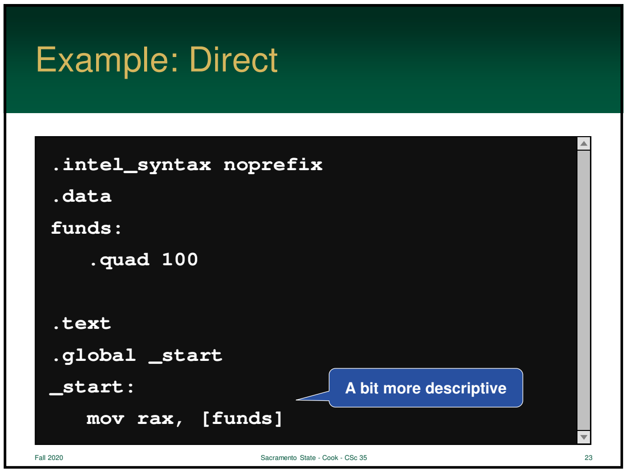

Example: Direct

```
.intel_syntax noprefix
.data
funds:
    .quad 100

.text
.global _start
_start:
    mov rax, [funds]
```

A bit more descriptive

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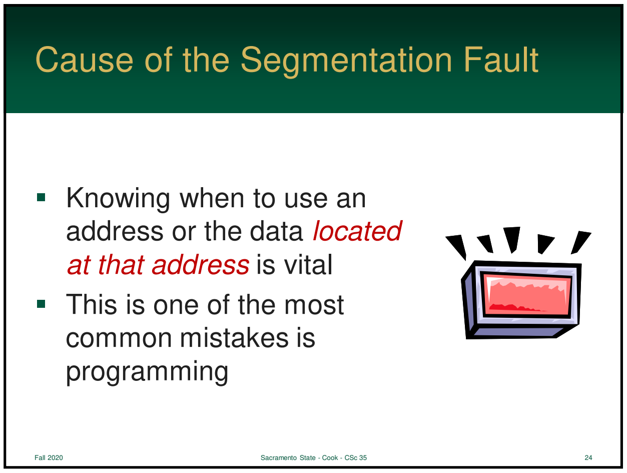

Cause of the Segmentation Fault

- Knowing when to use an address or the data *located at that address* is vital
- This is one of the most common mistakes is programming

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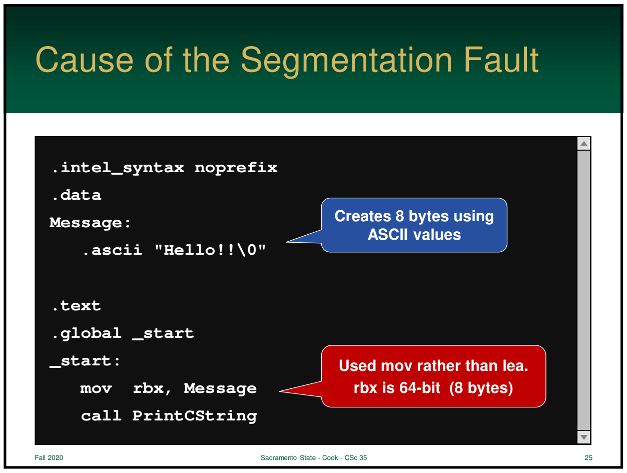

Cause of the Segmentation Fault

```
.intel_syntax noprefix
.data
Message:
    .ascii "Hello!!\0"

.text
.global _start
_start:
    mov  rbx, Message
    call PrintCString
```

Creates 8 bytes using ASCII values

Used mov rather than lea. rbx is 64-bit (8 bytes)

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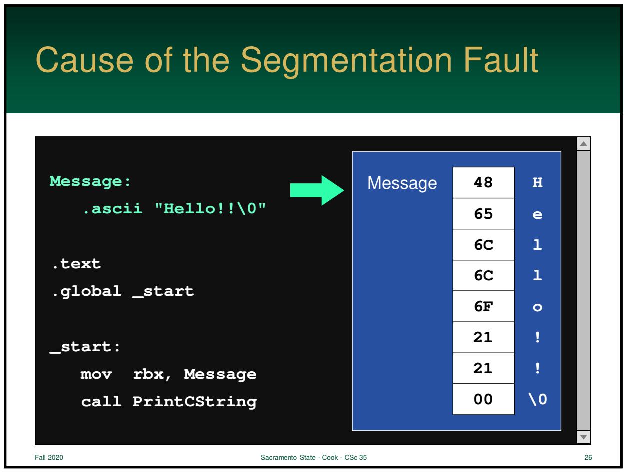

Cause of the Segmentation Fault

```
Message:
    .ascii "Hello!!\0"

.text
.global _start

_start:
    mov  rbx, Message
    call PrintCString
```

Message		
	48	H
	65	e
	6C	l
	6C	l
	6F	o
	21	!
	21	!
	00	\0

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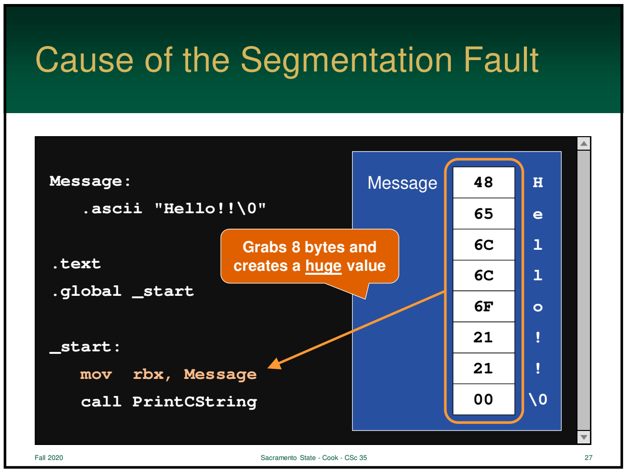

Cause of the Segmentation Fault

```
Message:
    .ascii "Hello!!\0"

.text
.global _start

_start:
    mov  rbx, Message
    call PrintCString
```

Grabs 8 bytes and creates a huge value

Message		
	48	H
	65	e
	6C	l
	6C	l
	6F	o
	21	!
	21	!
	00	\0

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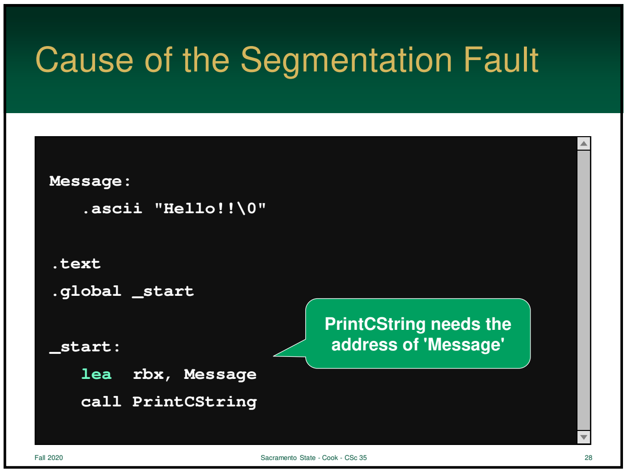

Cause of the Segmentation Fault

```
Message:
    .ascii "Hello!!\0"

.text
.global _start

_start:
    lea  rbx, Message
    call PrintCString
```

PrintCString needs the address of 'Message'

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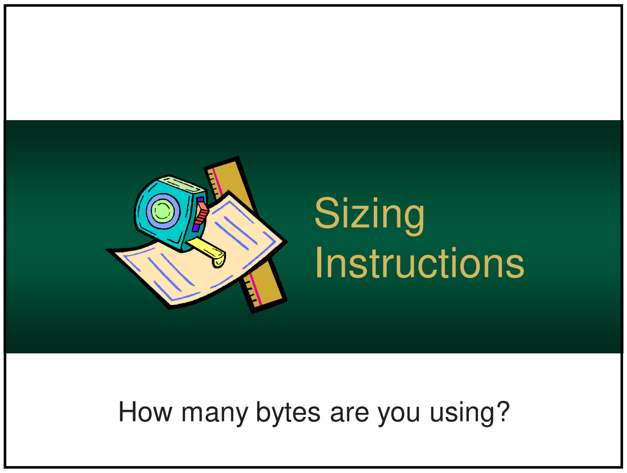

Sizing Instructions

How many bytes are you using?

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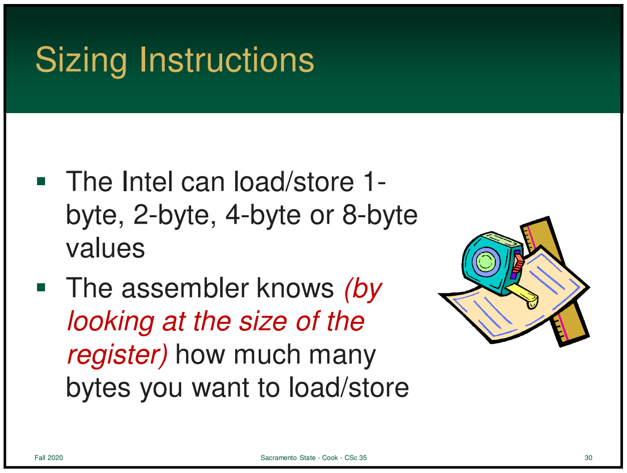

Sizing Instructions

- The Intel can load/store 1-byte, 2-byte, 4-byte or 8-byte values
- The assembler knows *(by looking at the size of the register)* how much many bytes you want to load/store

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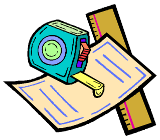
Sizing Instructions

- However, sometimes the number of bytes (1, 2, etc..) can't be determined
- In this case, the assembler will report an error
- … since it doesn't know how to encode the instruction



Example: How Many Bytes?

```
.intel_syntax noprefix
.data
total:
    .quad 0

.text
.global _start
_start:
    mov  total, 50
```

total is a target address. It doesn't have any implied size.

Example: How Many Bytes?

```
.intel_syntax noprefix
.data
total:
    .quad 0

.text
.global _start
_start:
    mov  total, 50
```

How many bytes is this? The value 50 can be stored in 1, 2, 4, or 8 bytes.

How Many Bytes?

- If it is not obvious to the assembler how many bytes you want to access, it will report *"ambiguous operand size"*
- To address this issue…
  - GAS assembly allows you places a single character after the instruction's mnemonic
  - this suffix will tell the assembler how many bytes will be accessed during the operation

How Many Bytes

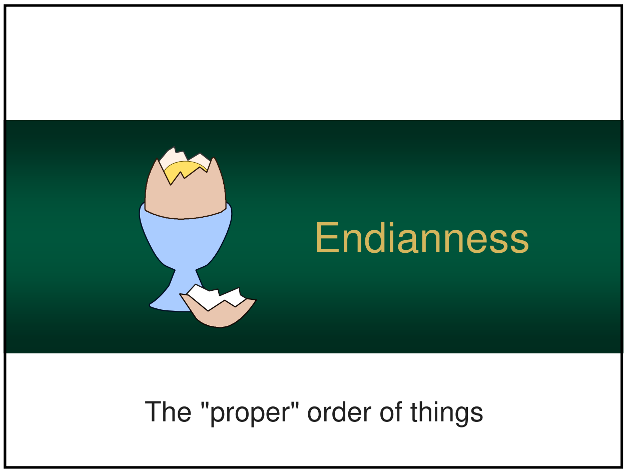
Suffix	Name	Size
b	byte	1 byte
s	short	2 bytes
l	long	4 bytes
q	quad	8 bytes

Example: Suffix Used

```
.intel_syntax noprefix
.data
total:
    .quad 0

.text
.global _start
_start:
    movq total, 50
```

Now the assembler knows you mean "move quad".



Endianness

The "proper" order of things

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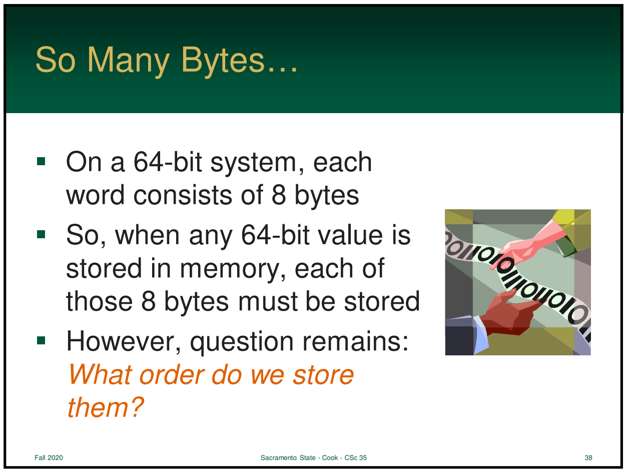

So Many Bytes…

- On a 64-bit system, each word consists of 8 bytes
- So, when any 64-bit value is stored in memory, each of those 8 bytes must be stored
- However, question remains: *What order do we store them?*

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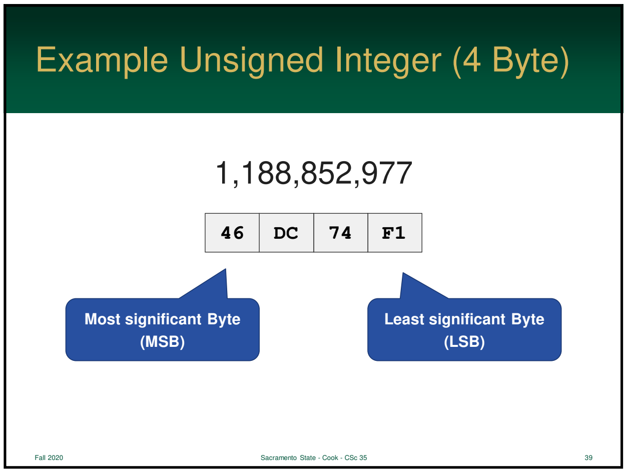

Example Unsigned Integer (4 Byte)

1,188,852,977

46	DC	74	F1

Most significant Byte (MSB)

Least significant Byte (LSB)

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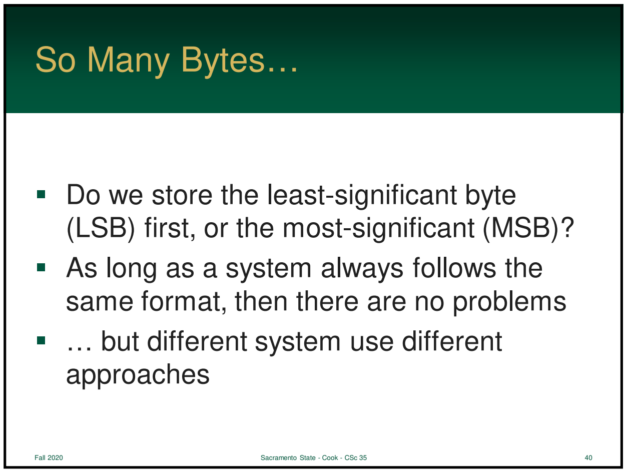

So Many Bytes…

- Do we store the least-significant byte (LSB) first, or the most-significant (MSB)?
- As long as a system always follows the same format, then there are no problems
- … but different system use different approaches

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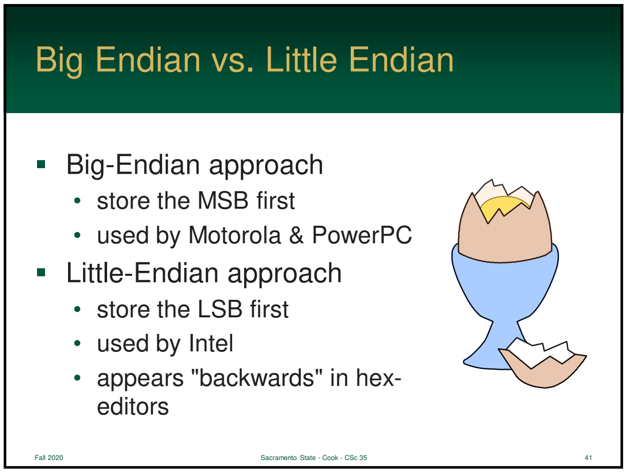

Big Endian vs. Little Endian

- Big-Endian approach
  - store the MSB first
  - used by Motorola & PowerPC
- Little-Endian approach
  - store the LSB first
  - used by Intel
  - appears "backwards" in hex-editors

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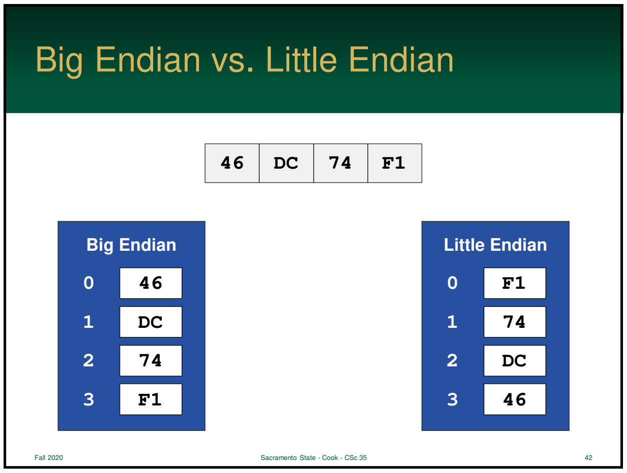

Big Endian vs. Little Endian

46	DC	74	F1

Big Endian

0	46
1	DC
2	74
3	F1

Little Endian

0	F1
1	74
2	DC
3	46

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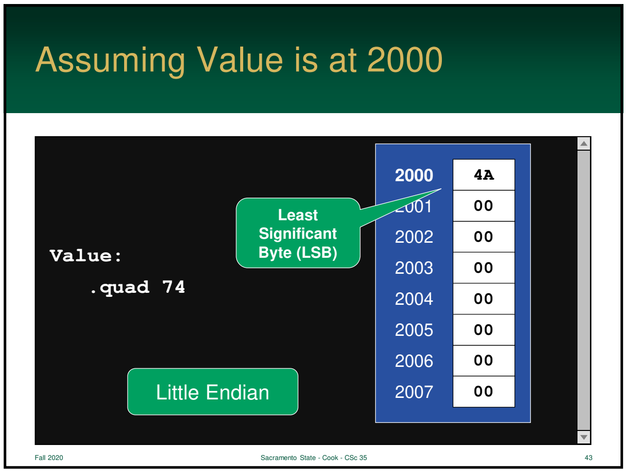

Assuming Value is at 2000

```
Value:
    .quad 74
```

2000	4A
2001	00
2002	00
2003	00
2004	00
2005	00
2006	00
2007	00

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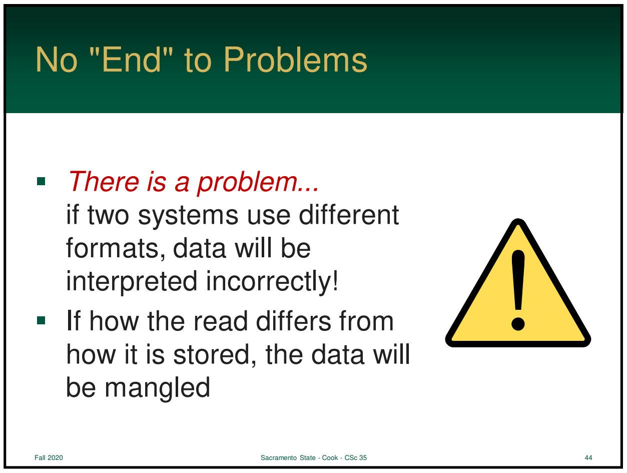

No "End" to Problems

- *There is a problem...* if two systems use different formats, data will be interpreted incorrectly!
- If how the read differs from how it is stored, the data will be mangled

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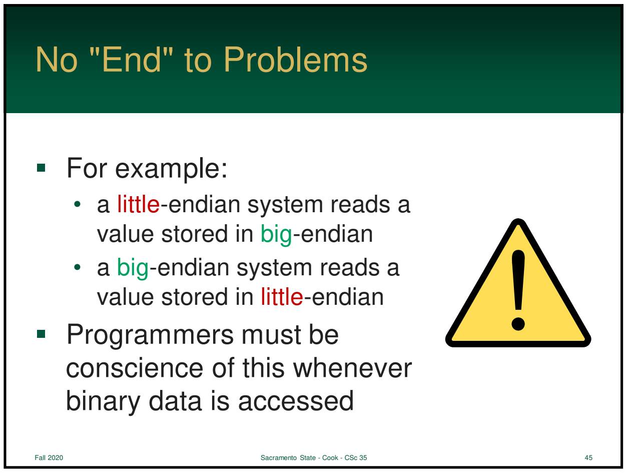

No "End" to Problems

- For example:
  - a little-endian system reads a value stored in big-endian
  - a big-endian system reads a value stored in little-endian
- Programmers must be conscience of this whenever binary data is accessed

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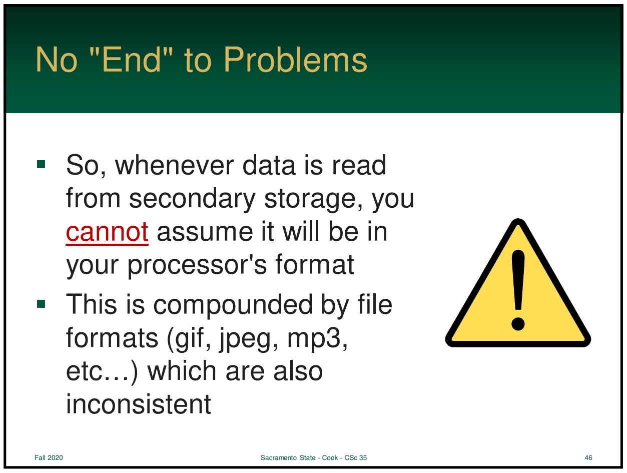

No "End" to Problems

- So, whenever data is read from secondary storage, you cannot assume it will be in your processor's format
- This is compounded by file formats (gif, jpeg, mp3, etc…) which are also inconsistent

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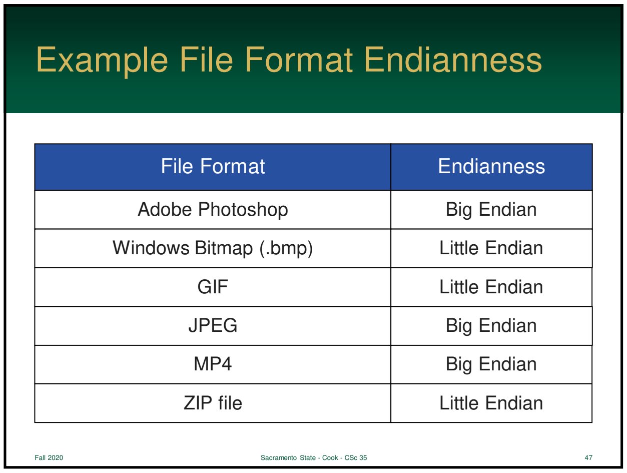

Example File Format Endianness

File Format	Endianness
Adobe Photoshop	Big Endian
Windows Bitmap (.bmp)	Little Endian
GIF	Little Endian
JPEG	Big Endian
MP4	Big Endian
ZIP file	Little Endian

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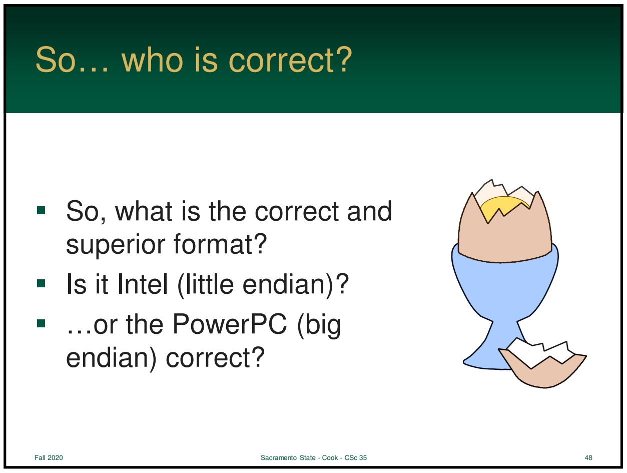

So… who is correct?

- So, what is the correct and superior format?
- Is it Intel (little endian)?
- …or the PowerPC (big endian) correct?

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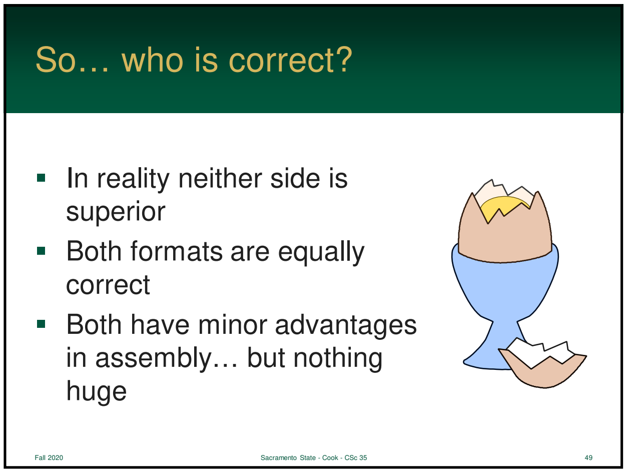

So… who is correct?

- In reality neither side is superior
- Both formats are equally correct
- Both have minor advantages in assembly… but nothing huge

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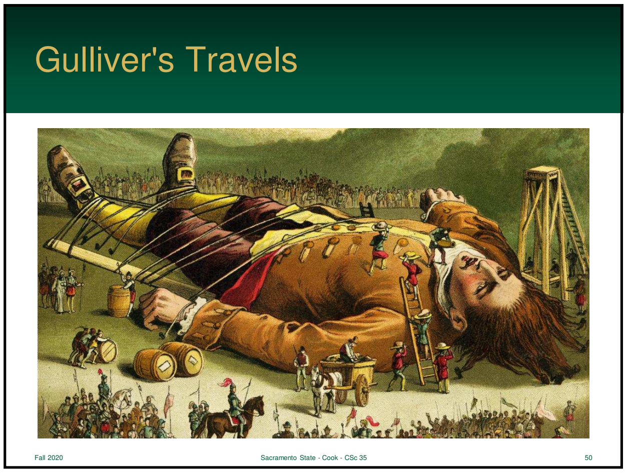

Gulliver's Travels

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