x86-64 Programming II

CSE 351 Autumn 2023

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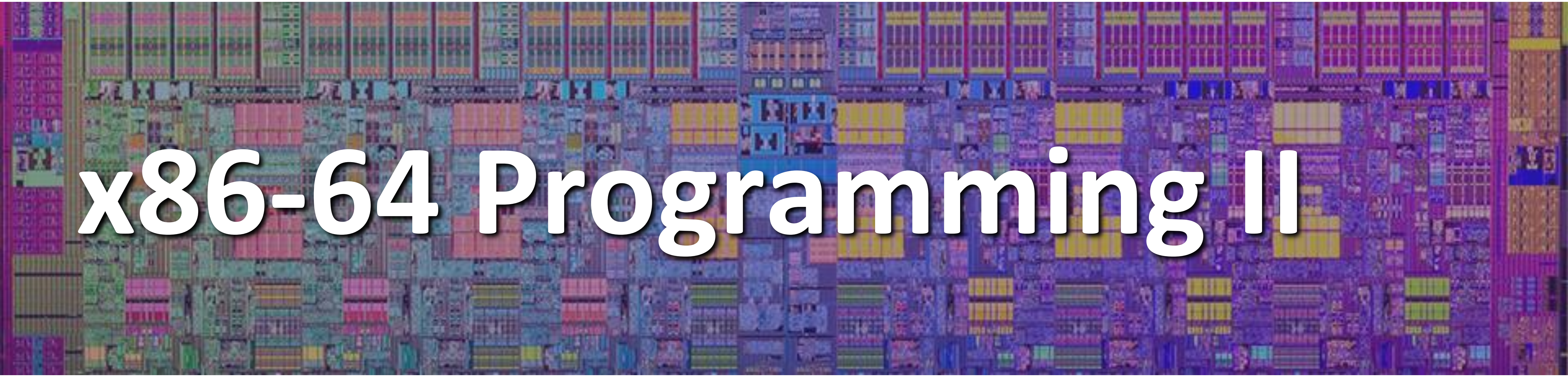
http://xkcd.com/99/

Relevant Course Information

- hw7 due Monday, hw8 due Wednesday
- Lab 1b due Monday (10/16) at 11:59 pm
  - No major programming restrictions, but should avoid magic numbers by using C macros (`#define`)
  - For debugging, can use provided utility functions `print_binary_short()` and `print_binary_long()`
  - Pay attention to the output of `aisle_test` and `store_test` – failed tests will show you actual vs. expected
  - You have *late day tokens* available



x86-64 Programming II

Lesson Summary (1/2)

- **Memory Addressing Modes:** The addresses used for accessing memory in `mov` (and other) instructions can be computed in several different ways
  - D(Rb,Ri,S) with *base register*, *index register*, *scale factor*, and *displacement* compute the address Reg[Rb] + Reg[Ri]*S + D and is usually dereferenced by instructions
  - These map well to pointer arithmetic operations
- **Load effective address** (`lea`) instruction used to compute addresses and perform basic arithmetic
  - *Doesn't* dereference the source memory operand, unlike all other instructions!
- **Extension instructions** (`movz`, `movs`) allow us to zero and sign extend data into longer widths

Lesson Summary (2/2)

- Terminology:
  - Memory Operand: displacement, base register, index register, scale factor
  - Extension instructions (`movz`, `movs`)
  - Address computation instruction (`lea`)
- Learning Objectives:
  - Without executing, describe the overall purpose of snippets of x86-64 assembly code containing arithmetic, [if-else statements, and/or loops].
  - Use GDB tools to step through a running program and extract debugging information from a program's disassembly, the state of registers, and values at specific memory locations.
- What lingering questions do you have from the lesson?

x86-64 Programming II – Context

Extension Instructions (Review)

2 width specifiers: b, w, l, q
1 2 4 8 bytes

- `movz__ src, dst` *# Move with zero extension*
  `movs__ src, dst` *# Move with sign extension*
  - Copy from a smaller source value to a larger destination
    - First suffix letter is size of source, second suffix letter is size of destination
    - Recall: zero-extension always fills with `0`, sign-extension fills with copy of the sign bit
  - `src` can be Mem or Reg; `dst` must be Reg

- Example: data shown in hex
  - `movzbq %al, %rbx`

1 byte

zero-extend

8 bytes

??	??	??	??	??	??	??	FF	←%rax
00	00	00	00	00	00	00	FF	←%rbx

zero-extend

Extension Instructions (Review)

- `movz__ src, dst` *# Move with zero extension*
  `movs__ src, dst` *# Move with sign extension*
  - Copy from a smaller source value to a larger destination
    - First suffix letter is size of source, second suffix letter is size of destination
    - Recall: zero-extension always fills with `0`, sign-extension fills with copy of the sign bit
  - `src` can be Mem or Reg; `dst` must be Reg

- Example: data shown in hex
  - `movsbl (%rax), %ebx`

4 bytes

sign-extend

1 byte from memory

Recall, *any x86-64 instruction* that stores into a 32-bit (suffix `l`) register zeros out the upper 4 bytes of the register.

pointer

00	00	7F	FF	C6	1F	A4	E8	←%rax

...	??	??	80	??	??	??	...	← MEM

copy

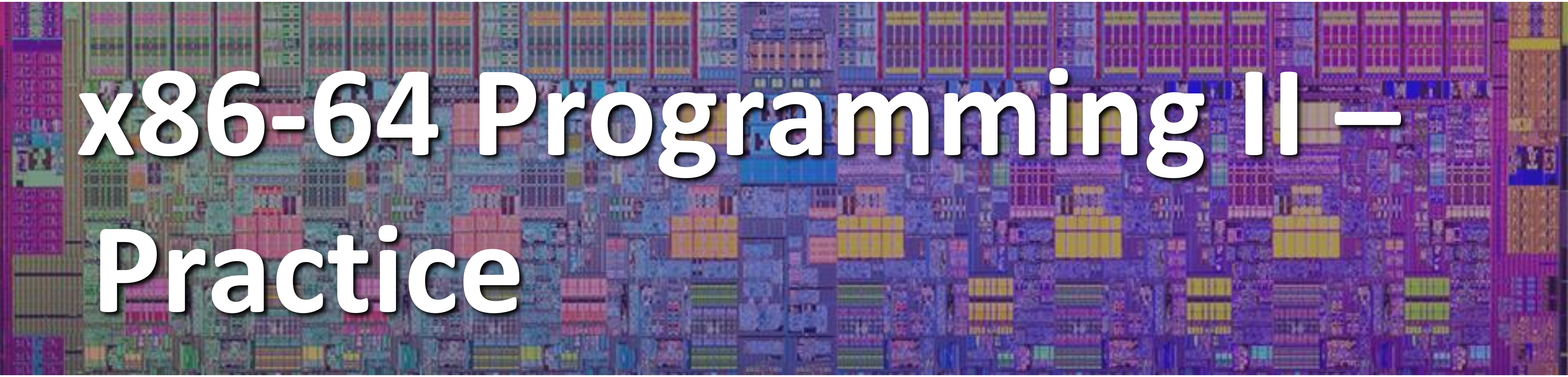
00	00	00	00	FF	FF	FF	80	←%rbx

zero out

sign-extend

GDB Demo

- The `movz` and `movs` examples on a real machine!
  - `movzbq %al, %rbx`
  - `movsbl (%rax), %ebx`
- You will need to use GDB to get through Lab 2
  - Useful debugger in this class and beyond!
- Pay attention to:
  - Setting breakpoints (`break`)
  - Stepping through code (`step`/`next` and `stepi`/`nexti`)
  - Printing out expressions (`print` – works with regs & vars)
  - Examining memory (`x`)



x86-64 Programming II – Practice

Group Work Time

- During this time, you are encouraged to work on the following:
  1) If desired, continue your discussion
  2) Work on the lesson problems (solutions at the end of class)
  3) Work on the homework problems

- Resources:
  - You can revisit the lesson material
  - Work together in groups and help each other out
  - Course staff will circle around to provide support

Practice Questions (1/2)

- `D(Rb,Ri,S)` computes address `Reg[Rb]+Reg[Ri]*S+D`
  - Likely will get dereferenced, but that's up to the instruction
  - Default values: `D` = `0`, `Reg[Rb]` = `0`, `Reg[Ri]` = `0`, `S` = `1`

- Assuming `%rdx` contains `0xF000` and `%rcx` contains `0x100`, what addresses are computed by the following memory operands?
  - `0x8(%rdx)`
  - `(%rdx,%rcx)`
  - `(%rdx,%rcx,4)`
  - `0x80(,%rdx,2)`

Practice Questions (2/2)

- Which of the following x86-64 instructions correctly calculates `%rax=9*%rdi`?
  - A. `leaq (,%rdi,9), %rax`
  - B. `movq (,%rdi,9), %rax`
  - C. `leaq (%rdi,%rdi,8), %rax`
  - D. `movq (%rdi,%rdi,8), %rax`