

# x86-64 Programming IV

CSE 351 Autumn 2023

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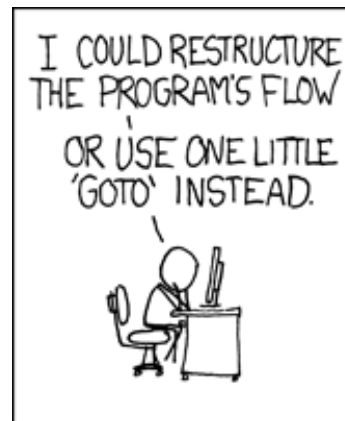
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<http://xkcd.com/571/>

# Relevant Course Information

- ❖ Lab 1a regrade requests open on Gradescope
- ❖ Lab 1b submissions close tonight
- ❖ Lab 2 due next Friday (10/27)
  - Section tomorrow on to help prep you for Lab 2 – use the midterm reference sheet & bring your laptop!
  - Optional GDB Tutorial in Ed Lessons
- ❖ Midterm (take home, 11/2–11/4)
  - Make notes and use the [midterm reference sheet](#)
  - Form study groups and look at past exams!

A detailed, colorful micrograph of a microchip die, showing a complex grid of circuitry and various colored regions (purple, blue, yellow, green, red) representing different functional blocks.

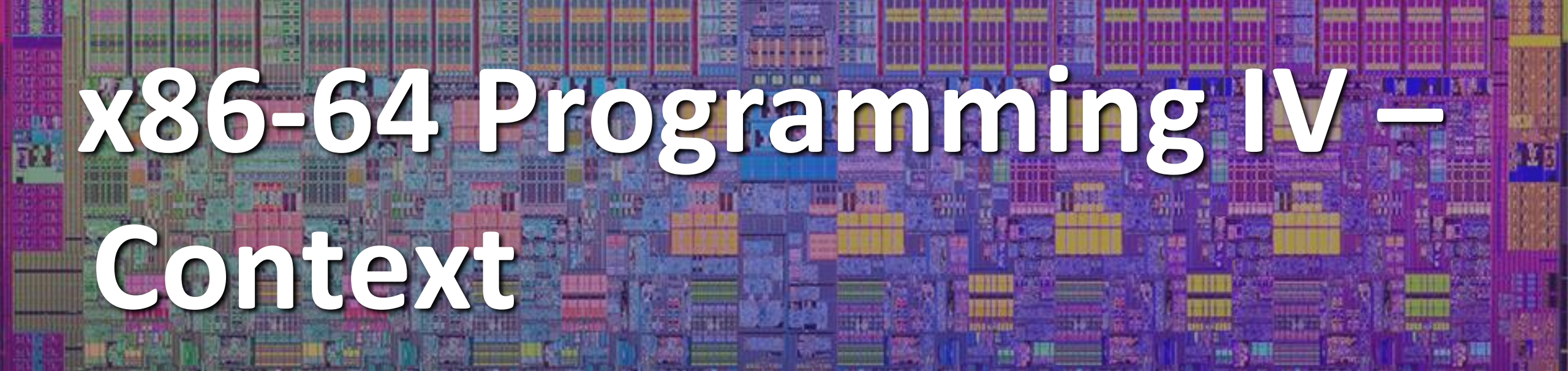
# x86-64 Programming IV

# Lesson Summary (1/2)

- ❖ Most control flow constructs (*e.g.*, if-else, for-loop, while-loop) can be implemented in assembly using combinations of conditional and unconditional jumps
  - Differences come from placement of jumps and whether they jump forward or backwards in code
- ❖ Switch statements can be implemented using jump tables and indirect jump instructions
  - Jump tables are arrays of pointers to code blocks
  - Indirect jump jumps to address stored somewhere in memory instead of target specified in instruction

# Lesson Summary (2/2)

- ❖ Terminology:
  - Jump table, indirect jump
  
- ❖ Learning Objectives:
  - Without executing, describe the overall purpose of snippets of x86-64 assembly code containing arithmetic, if-else statements, and/or loops.
  
- ❖ What lingering questions do you have from the lesson?

A detailed, colorful micrograph of a microchip die, showing intricate circuit patterns in shades of purple, blue, yellow, and green. The text is overlaid on this background.

# x86-64 Programming IV – Context

# Labels & Jumps in C (goto)

- ❖ C allows goto as means of transferring control (jump)
  - Closer to assembly programming style
  - Generally considered bad coding style

```
long absdiff(long x, long y) {  
    long result;  
    if (x > y)  
        result = x-y;  
    else  
        result = y-x;  
    return result;  
}
```

```
long absdiff_j(long x, long y) {  
    long result;  
    int ntest = (x <= y);  
    if (ntest) goto Else;  
    result = x-y;  
    goto Done;  
Else:  
    result = y-x;  
Done:  
    return result;  
}
```

conditional jump → cmp, jle

unconditional jump → goto, jmp

labels (addresses) → Else:, Done:

# Labels & Jumps in C (goto)

- ❖ C allows goto as means of transferring control (jump)
  - Closer to assembly programming style
  - Generally considered bad coding style... listen to Kernighan & Ritchie:

## 3.8 Goto and Labels

C provides the infinitely-abusable goto statement, and labels to branch to. Formally, the goto is never necessary, and in practice it is almost always easy to write code without it. We have not used goto in this book.

Nevertheless, there are a few situations where gotos may find a place. The most common is to abandon processing in some deeply nested structure, such as breaking out of two or more loops at once. The break statement cannot be used directly since it only exits from the innermost loop. Thus:



# Mainstream ISAs, Revisited



## x86

|                   |   |
|-------------------|---|
| <b>Designer</b>   | Intel, AMD                                  |
| <b>Bits</b>       | 16-bit, 32-bit and 64-bit                   |
| <b>Introduced</b> | 1978 (16-bit), 1985 (32-bit), 2003 (64-bit) |
| <b>Design</b>     | CISC  |
| <b>Type</b>       | Register-memory                             |
| <b>Encoding</b>   | Variable (1 to 15 bytes)                    |
| <b>Branching</b>  | Condition code                              |
| <b>Endianness</b> | Little                                      |

Macbooks & PCs  
(Core i3, i5, i7, M)  
[x86-64 Instruction Set](#)



## ARM

|                   |   |
|-------------------|---|
| <b>Designer</b>   | Arm Holdings  |
| <b>Bits</b>       | 32-bit, 64-bit  |
| <b>Introduced</b> | 1985  |
| <b>Design</b>     | RISC  |
| <b>Type</b>       | Register-Register   |
| <b>Encoding</b>   | AArch64/A64 and AArch32/A32 use 32-bit instructions, T32 (Thumb-2) uses mixed 16- and 32-bit instructions; ARMv7 user-space compatibility. <sup>[1]</sup> |
| <b>Branching</b>  | Condition code, compare and branch  |
| <b>Endianness</b> | Bi (little as default)  |

Smartphone-like devices  
(iPhone, iPad, Raspberry Pi)  
[ARM Instruction Set](#)



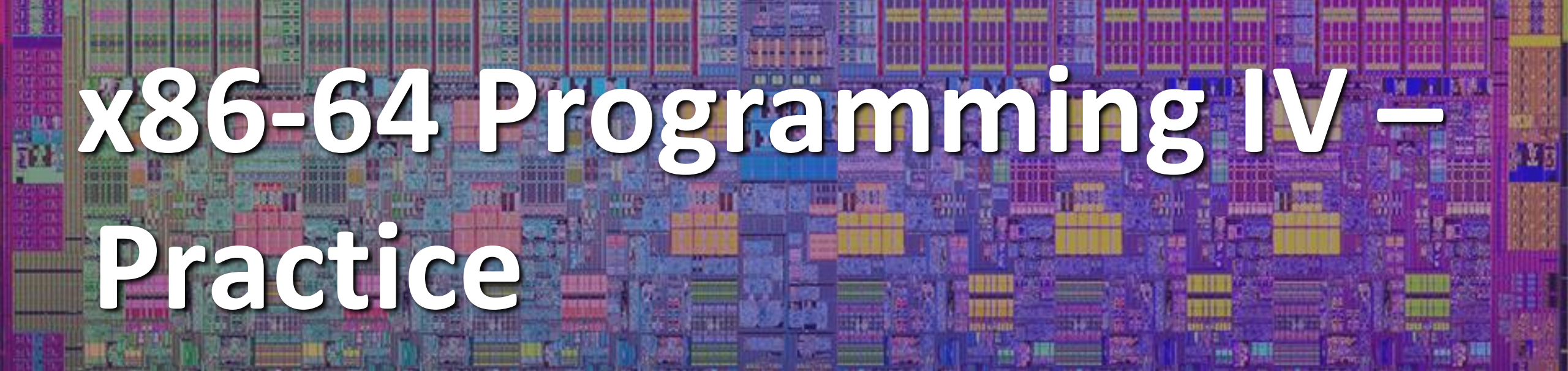
## RISC-V

|                   |                                    |
|-------------------|------------------------------------|
| <b>Designer</b>   | University of California, Berkeley |
| <b>Bits</b>       | 32 · 64 · 128                      |
| <b>Introduced</b> | 2010                               |
| <b>Design</b>     | RISC                               |
| <b>Type</b>       | Load-store                         |
| <b>Encoding</b>   | Variable                           |
| <b>Endianness</b> | Little <sup>[1][3]</sup>           |

Mostly research  
(some traction in embedded)  
[RISC-V Instruction Set](#)

# Discussion Question

- ❖ Discuss the following question(s) in groups of 3-4 students
  - I will call on a few groups afterwards so please be prepared to share out
  - Be respectful of others' opinions and experiences
  
- ❖ We taught you assembly using x86-64; you didn't have a choice
  - What are some of the advantages and drawbacks of this choice?
  
  - What are some possible assumptions we are making about our students or values we are forcing on our students with this choice?

A detailed, colorful micrograph of a microchip die, showing intricate patterns of circuitry in shades of purple, blue, yellow, and green. The text is overlaid on this background.

# x86-64 Programming IV – 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 Question

- ❖ The following is assembly code for a for-loop; identify the corresponding parts (Init, Test, Update)

- $i \rightarrow \%eax$ ,  $x \rightarrow \%rdi$ ,  $y \rightarrow \%esi$

| Line | Assembly                 | Annotation                             |          |
|------|--------------------------|--|----------|
| 1    | movl \$0, %eax           | ← Init                                 |          |
| 2    | .L2: cmpl %esi, %eax     | } !Test → $i - y \geq 0$<br>$i \geq y$ |          |
| 3    | jge .L4                  |  |          |
| 4    | movslq %eax, %rdx        | ← loop                                 |          |
| 5    | leaq (%rdi,%rdx,4), %rcx |  |          |
| 6    | movl (%rcx), %edx        |  |          |
| 7    | addl \$1, %edx           |  |          |
| 8    | movl %edx, (%rcx)        |  |          |
| 9    | addl \$1, %eax           |  | ← Update |
| 10   | jmp .L2                  |  |          |
| 11   | .L4:                     |  | exit     |

for( int i = 0 ; i < y ; i++ )

Init                      Test                      Update