Procedures I

CSE 351 Autumn 2023

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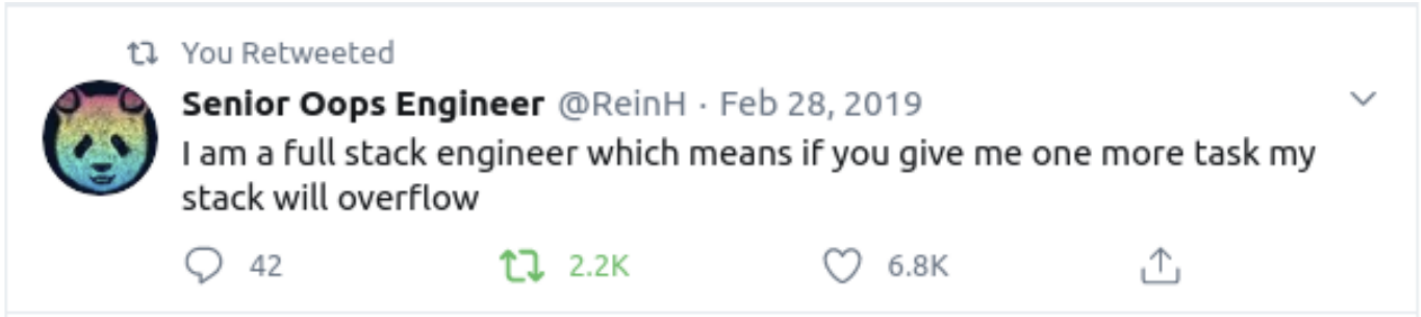


Relevant Course Information

- Lab 2 due next Friday (10/27)
  - Can start in earnest after today's lecture!
  - See GDB Tutorial Lesson and and Phase 1 walkthrough in Section 4 Lesson

- Midterm (take home, 11/2–11/4)
  - Make notes and use the midterm reference sheet
  - Form study groups and look at past exams!

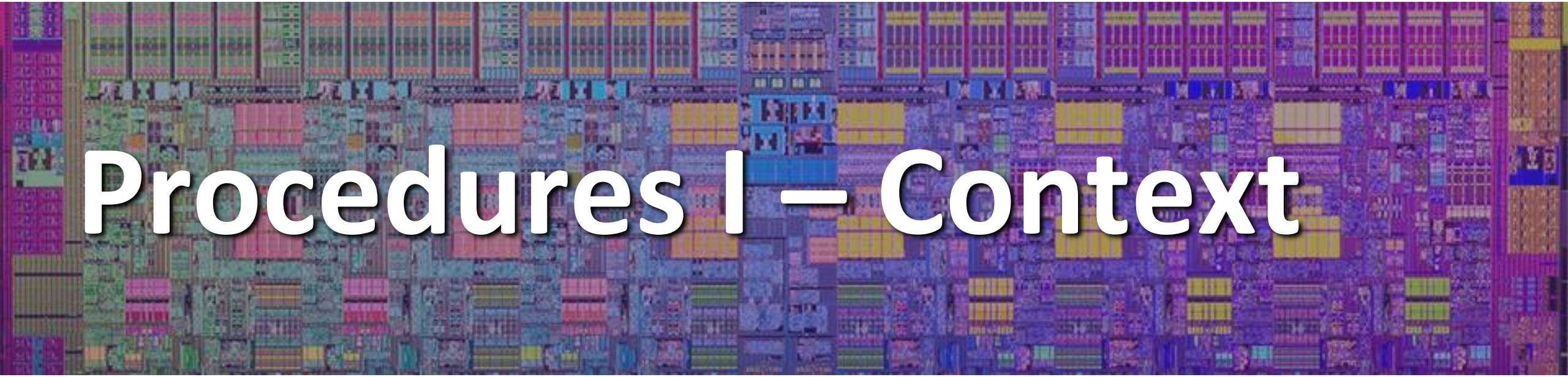
Procedures I

Lesson Summary (1/2)

- Memory is organized into 5 segments (Stack, Heap, Static Data, Literals, Instructions/Code) based on data declaration and lifetime
  - Goals: maximize use of space, manage data differently, apply separate permissions
  - The Stack is at the highest addresses and grows downward; can manipulate using `add`, `sub`, `push`, and `pop`
- Procedure calling conventions for passing control and data
  - `call` and `ret` pass control using `%rip` and a return address on the stack
  - Return value: `%rax`, Arguments: `%rdi`, `%rsi`, `%rdx`, `%rcx`, `%r8`, `%r9`, Stack
- Stack organized into stack frames that hold a procedure instance's data

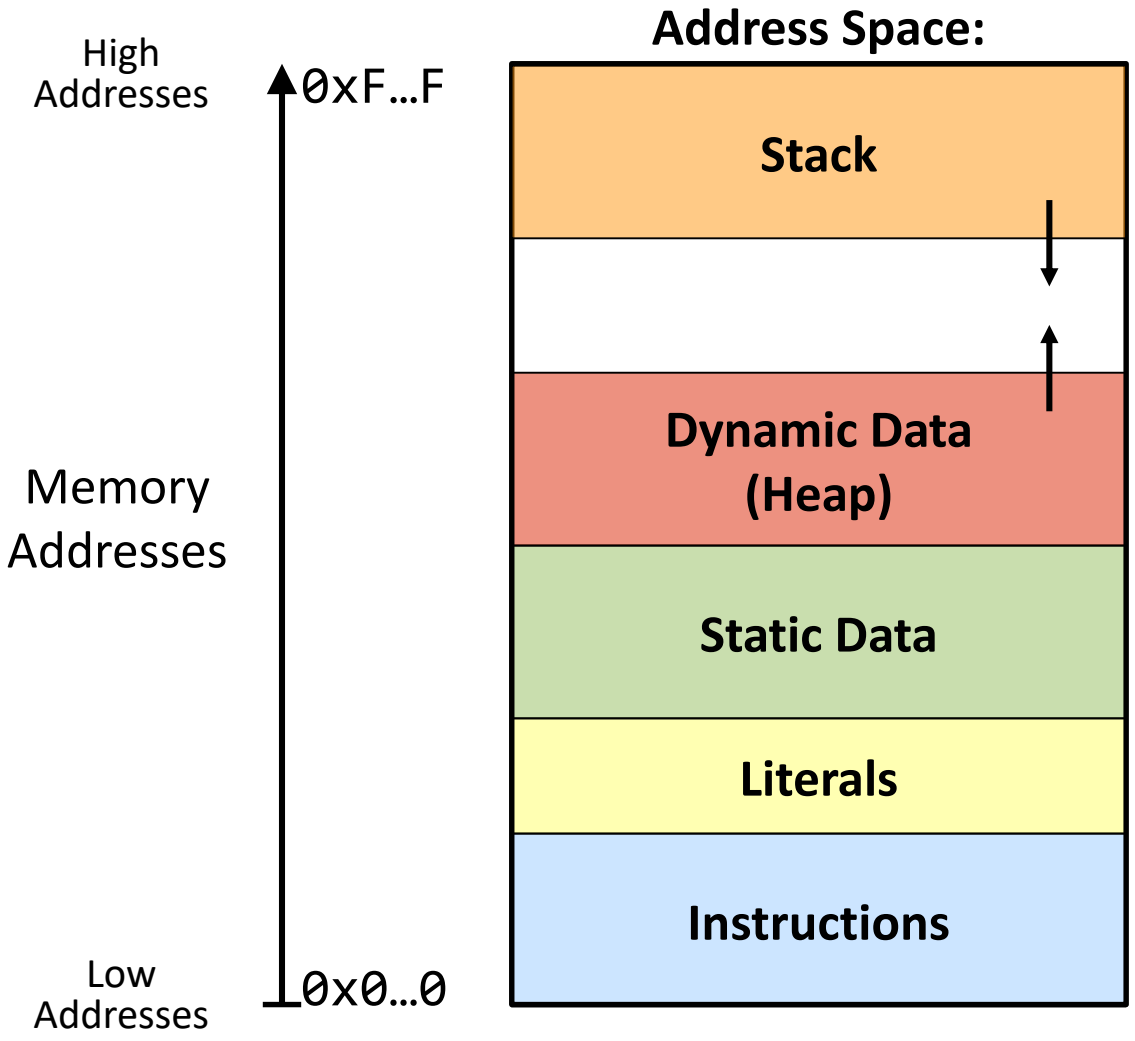
Lesson Summary (2/2)

- Terminology:
  - Stack, Heap, Static Data, Literals, Instructions/Code
  - Stack pointer (`%rsp`), `push`, `pop`
  - Caller, callee, return address, `call`, `ret`
  - Stack frames and stack discipline
- Learning Objectives:
  - Determine the location/segment in memory that a piece of data will be stored based on the nature of that data (*i.e.*, static, literals, etc.).
  - Trace stack frame movement and creation.
- What lingering questions do you have from the lesson?



Procedures I – Context

Simplified Memory Layout



What Goes Here:

Local variables and procedure context

Variables allocated with new or `malloc`

Static variables (including global variables)

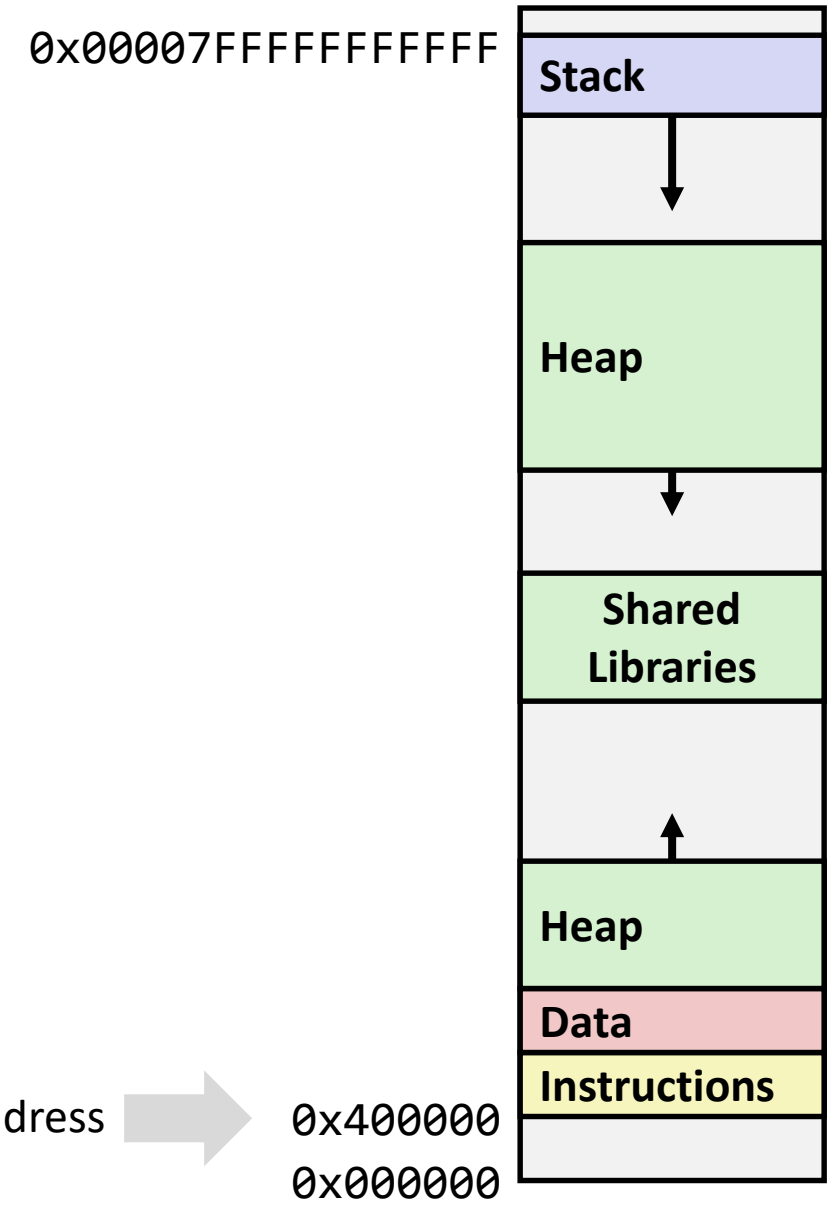
Immutable literals/constants (*e.g.*, `"example"`)

Program code

x86-64 Linux Memory Layout

This is extra (non-testable) material

- Stack
  - Runtime stack has 8 MiB limit
- Heap
  - Dynamically allocated as needed
  - `malloc()`, `calloc()`, `new`, …
- Statically allocated data (Data)
  - Read-only: string literals
  - Read/write: global arrays and variables
- Code / Shared Libraries
  - Executable machine instructions
  - Read-only



Stack Overflow

- When the stack pointer exceeds the stack bounds (segmentation fault)
  - In theory: when it collides with the Heap
  - In x86-64 Linux, when it exceeds 8 MiB limit

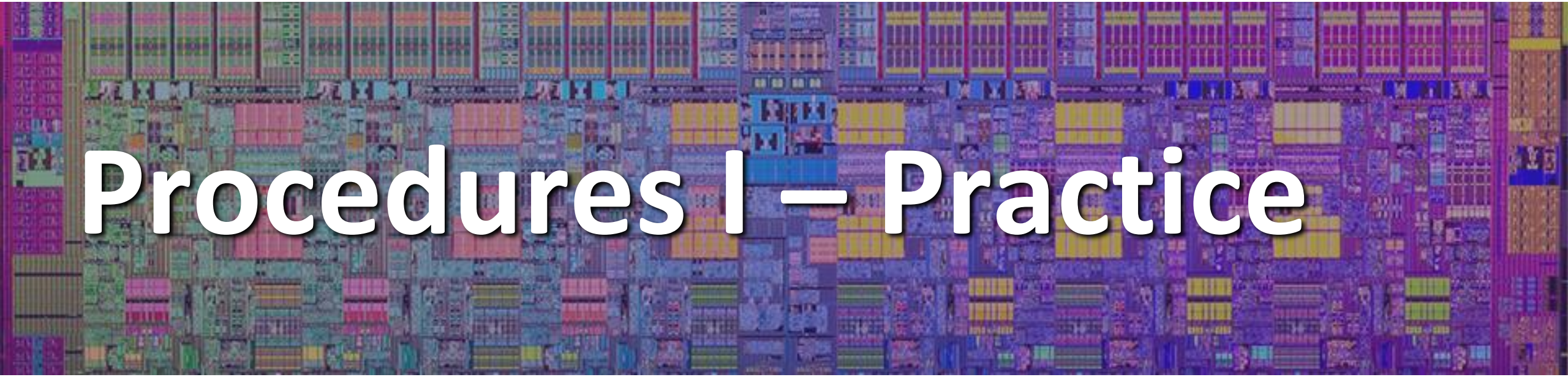
Aside: Stack Overflow

- Has nothing to do with actual stack overflow – named based on poll of blog users; some of the non-winning options:
  - algorithmical
  - bitoriented
  - dereferenced
  - fellowhackers
  - humbleprogrammers
  - privatevoid
  - shiftleft1
  - understandrecursion
- Crowd-sourced their logo for $512

Discussion Questions

- 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

- Naming/etymology plays a big role in learning
  - Which new terms in this class have been the most intuitive for you to learn vs. the most difficult?
  - What do you think goes into a good vs. bad name more generally in computer science?



Procedures I – 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)

- How does the stack change after executing the following instructions?

```
pushq %rbp
subq  $0x18, %rsp
```

- For the following function, which registers do we know *must* be used?

```
void* memset(void* ptr, int value, size_t num);
```

Practice Questions (2/2)

- Answer the following questions about when `main()` is run (assume `x` and `y` stored on the Stack):

```
int main() {
    int i, x = 0;
    for(i=0;i<3;i++)
        x = randSum(x);
    printf("x = %d\n",x);
    return 0;
}
```

```
int randSum(int n) {
    int y = rand()%20;
    return n+y;
}
```

  - *Higher/larger address*: `x` or `y`?
  - How many total stack frames are *created*?
  - What is the maximum *depth* (# of frames) of the Stack?

A. 1 B. 2 C. 3 D. 4