Intro, C refresher
CSE 333

Instructor: Alex Sanchez-Stern (he/him)

Teaching Assistants:
Audrey Seo (they/them)
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Katie Gilchrist (she/her)

Lecture Outline

- **Course Introduction**
- Course Policies
  - https://courses.cs.washington.edu/courses/cse333/25su/syllabus.html
- C Intro

Introductions: Course Staff

- Instructor: Alex Sanchez-Stern (asnchstr@cs)
- 4 TAs:
  - Audrey Seo, Deeksha Vatwani, Derek de Leuw, Katie Gilchrist
  - Available in section, office hours, and on the ed board
  - An invaluable source of information and help
- Get to know us
  - We are here to help you succeed!

Communication

- Website: http://cs.uw.edu/333
  - Schedule, policies, materials, assignments, etc.

- Office Hours: spread throughout the week, available on the class calendar

- One-on-ones: by appointment
  - Send us a message with your availability in the next 3 days
  - Do **not** expect a response in less than 24 hours!

Communication

- Discussion: Ed group linked to course home page
  - Ask and answer questions – staff will monitor and contribute
  - Use private messages for questions about detailed code, etc.
- Announcements: will use broadcast Ed messages to send "things everyone must read and know"
- Messages to staff: things unsuitable for Ed board or Gradescope regrade requests
  - Please send email to cse333-staff@cs.uw.edu. Reaches all staff so the right person can help out quickly, and helps follow up until resolved
  - (***don't*** email to instructor or individual TAs if possible – we can get quick answers for you and coordinate better if it goes to the staff

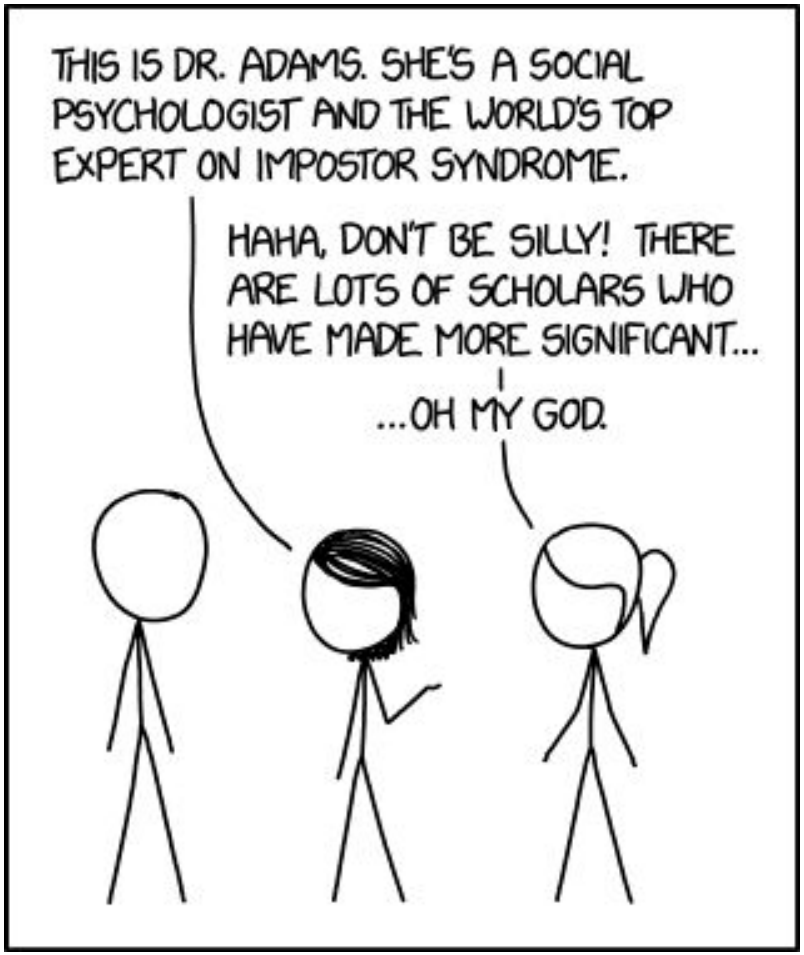
Introductions: Students

- ~70 students this quarter

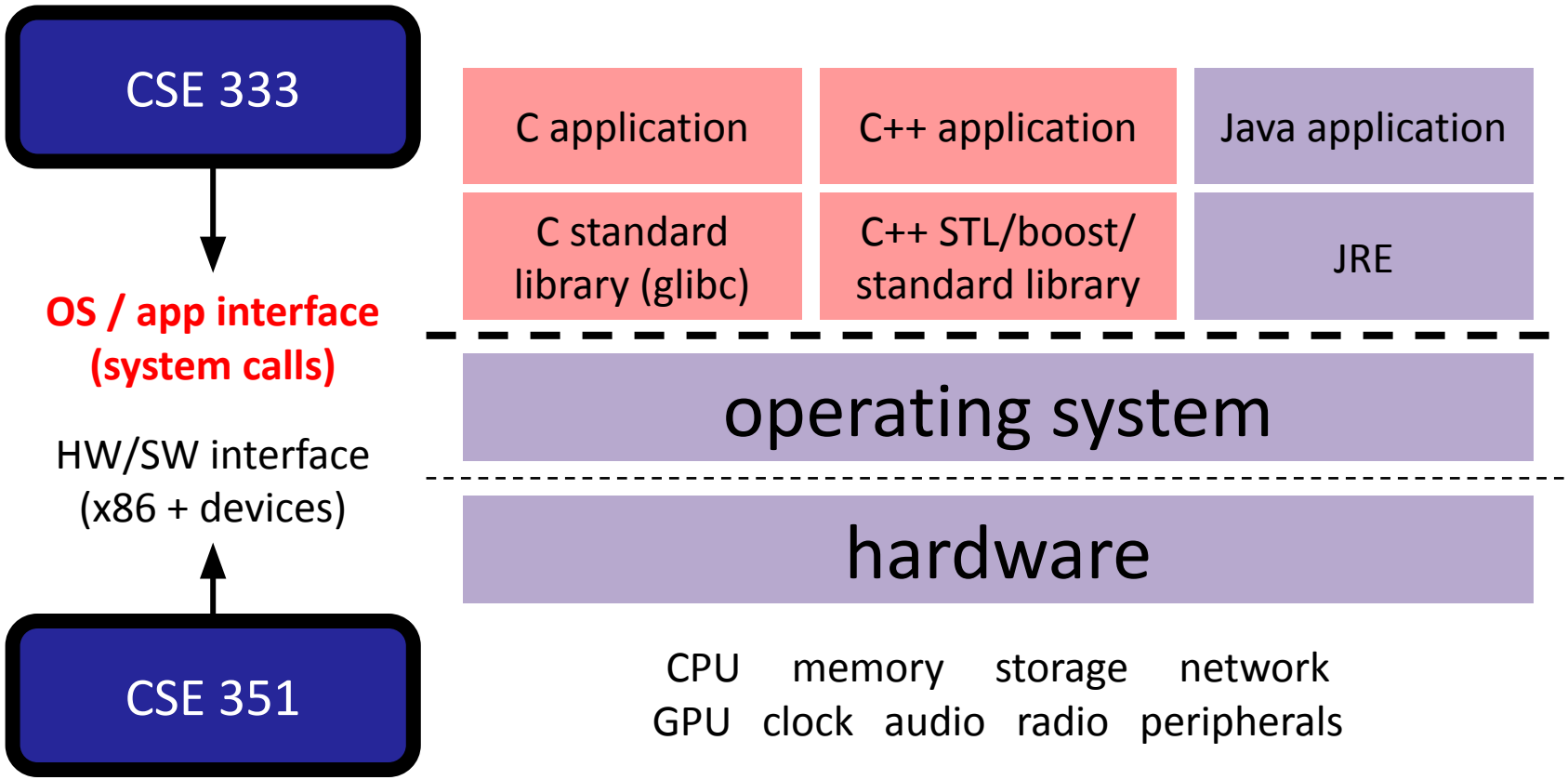
- Expected background
  - **Prereq:** CSE 351 – C, pointers, memory model, linker, system calls
  - CSE 391 or Linux skills needed for CSE 351 assumed

Introductions: Students

- "Nearly 70% of individuals will experience signs and symptoms of impostor phenomenon at least once in their life."
  - https://en.wikipedia.org/wiki/Impostor_syndrome
- If you're confused, probably others are too. Speak up and you'll save someone else!



Course Map: 100,000 foot view



Systems Programming

- The programming skills, knowledge, and engineering discipline you need to build a system
  - **Knowledge:** long list of interesting topics
    - Concurrency, OS interfaces and semantics, techniques for consistent data management, distributed systems algorithms, …
    - Most important: a deep(er) understanding of the "layer below"
  - **Discipline:** testing, debugging, performance analysis, code quality

Code Quality

- Learning to writing clean code is a lifelong process
- Good code quality will help you in the long run
  - Complexity is tamed by good habits and good abstractions
  - Systems code is complex!
  - Easy to understand code now will help you later.
- So use these:
  - Coding style conventions
  - Unit testing, code coverage testing, regression testing
  - Documentation (code comments, design docs)
  - Code reviews

Lecture Outline

- Course Introduction
- **Course Policies**
  - https://courses.cs.washington.edu/courses/cse333/24su/syllabus.html
- C Intro

This is Only an Overview!

- This is just the summary/highlights
  - … but you must read the full details online!

https://courses.cs.washington.edu/courses/cse333/24su/syllabus.html

Course Components

- Lectures (24)
  - Introduce the concepts; take notes!!!
  - Materials are posted at 6:00pm the night before
- Sections (9)
  - Applied concepts, important tools and skills for assignments, clarification of lectures, exam review and preparation
- Final exam and midterm
  - Goal is to revisit and internalize concepts
  - Tests will be **handwritten**: relying too much on your IDE will come back to bite you!

Course Components

- Programming Exercises (~18)
  - Roughly one per lecture, due the morning before the next lecture
  - Coarse-grained grading (check plus/check/check minus = 0, 1, 2, or 3)
- Programming Projects (0+4)
  - Warmup, then 4 "homeworks" that build on each other
  - Individual work
- Lecture Activities (~40)
  - In-class polls graded on *completion* not *correctness*
  - Lecture activities can be made up only for *particular hardship*
  - But since life can get in the way, three days of missed lecture activities will be dropped

Grading

- **Exercises:** ~30%
  - Submitted via Gradescope
  - Evaluated on correctness and code quality; drop the lowest score
- **Homeworks:** ~30%
  - Submitted via GitLab; must tag commit that you want graded
  - "Does it work?" and code quality both matter, roughly equally
  - Binaries provided if you didn't get previous part working or prefer to start with a known good solution to previous parts
- **Lecture Activities:** ~15%
- **Midterm**: ~10%
- **Final:** ~15%

Deadlines and Student Conduct

- Late policies
  - Exercises
    - no late submissions accepted
    - due 10 am before class
  - Homeworks:
    - 4 late days for entire quarter
    - max 2 per project
  - We will work with you if unusual circumstances / problems

Deadlines and Student Conduct

- Academic Integrity (**read** the full policy on the web)
  - This does ***not*** mean suffer in silence; study groups and discussions are a great way to learn!
  - Just don't share or copy code or answers directly

LLMs, Chatbots, and AI Coding Tools

- These new tools are everywhere
  - You might even end up using them in your future jobs
  - They can be powerful when used carefully in certain settings

- But for this class, you can't use (most of) them
  - We're learning to do things the hard way, for a strong foundation
  - There's some emerging evidence that usage of AI tools decreases your cognitive abilities

[1] "Your Brain on ChatGPT: Accumulation of Cognitive Debt when Using an AI Assistant for Essay Writing Task" https://arxiv.org/abs/2506.08872

LLMs, Chatbots, and AI Coding Tools

- **Don't** use AI-enabled editors or tools

- **Don't** ask any chatbots questions like:
  - "How do I fix this code?"
  - "Can you write me a function that…"
  - "How do I finish this assignment?"

- I reserve the right to ask you into my office to explain any code you've submitted for this class

LLMs, Chatbots, and AI Coding Tools

- If it helps you, you **can** ask LLMs questions like:
  - "How are pointers related to arrays in C?"
  - "Can you explain OS system calls? I don't understand X"
  - "What is the function called that runs whenever I create a new object in C++?"

- But **always** check the answer with a second source
  - Making things up is still a serious problem with these tools
  - Don't answer another students question with a chatbot response; always use the primary source

Gadgets

Please:

- Keep your laptop usage to class-related materials.
- People behind you can see your screen, and it can be really distracting!
- The only app you should be using on your phone is PollEverywhere

Starting…. NOW!

- First exercise out today, due Wednesday morning **10am** before class
- HW0 (the warmup project) published wednesday, due next Monday

- Goal is to figure out setup and computing infrastructure right away so we don't put that off and then have a crunch later in the quarter

- Logistics for larger projects explained in sections Thursday
  - It's okay to ignore the homework details until section on Thursday, but try to start the setup
  - Bring a laptop to sections! We may have time to go through some of the initial configuration parts for hw0.

Lecture Outline

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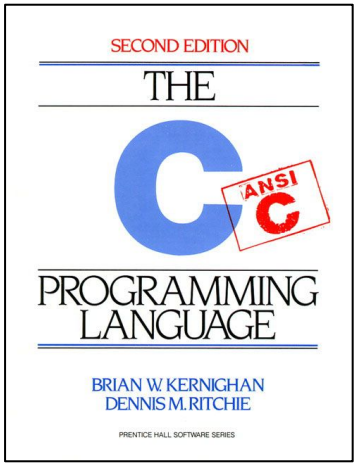
- **C Intro**
  - **Workflow, Variables, Functions**

C



- Created in 1972 by Dennis Ritchie
  - Designed for creating system software
  - Portable across machine architectures
  - More recently updated in 1999 (C99) and 2011 (C11) and 2017 (C17)
- Characteristics
  - "Low-level" language that allows us to exploit underlying features of the architecture – but easy to fail spectacularly (!)
  - Procedural (not object-oriented)
  - Typed but unsafe (often necessary to bypass the type system)
  - Small standard library compared to Java, C++, most others….

Generic C Program Layout

```
#include <system_files>
#include "local_files"

#define macro_name macro_expr


/* declare functions */
/* declare external variables & stru

int main(int argc, char* argv[]) {
  /* the innards */
}

/* define other functions */
```

We'll cover this stuff late next week

We'll cover this stuff today

C Syntax: `main`

- All programs start with `main`:

```
int main(int argc, char* argv[]){
```

- What do the arguments mean?
  - `argc` contains the number of strings on the command line (the executable name counts as one, plus one for each argument).
  - `argv` is an array containing *pointers* to the arguments as strings (more on arrays and pointers later).
- Example: `$ ./foo hello 87`
  - `argc = 3`
  - `argv[0]="./foo", argv[1]="hello", argv[2]="87"`

When Things Go Wrong…

- Processes return an "exit code" when they terminate
  - Can be read and used by parent process (shell or other)
    - In main: return EXIT_SUCCESS; or return EXIT_FAILURE; (e.g., 0 or 1)
- In C, functions do the same!
  - C does not have exception handling (no `try`/`catch`)
  - Errors are returned as integer error codes from functions
  - Because of this, it's easy to miss an important error
- Crashes
  - If you do something bad, you hope to get a "segmentation fault" (believe it or not, this is the "good" option)

Java vs. C (351 refresher)

- Are Java and C mostly similar (S) or significantly different (D) in the following categories?
  - List any differences you can recall (even if you put 'S')

Language Feature	S/D	Differences in C
Control structures	S	
Primitive datatypes	S/D	Similar but sizes can differ (char, esp.), unsigned, no boolean, uninitialized data, …
Operators	S	Java has >>>, C has ->
Casting	D	Java enforces type safety, C does not
Arrays	D	Not objects, don't know their own length, no bounds checking
Memory management	D	Manual (malloc/free), no garbage collection

Primitive Types in C

- Integer types
  - `char`, `int`
- Floating point
  - `float`, `double`
- Modifiers
  - `short` [int]
  - `long` [int]
  - `signed` [char, int]
  - `unsigned` [char, int]

No standard size!
Can depend on architecture, compiler, etc.

Size technically also unspecified, but pretty much always the same

C99 Extended Integer Types

- Solves the conundrum of "how big is an `long int`?"

```
#include <stdint.h>

void foo(void) {
  int8_t  a;  // exactly 8 bits, signed
  int16_t b;  // exactly 16 bits, signed
  int32_t c;  // exactly 32 bits, signed
  int64_t d;  // exactly 64 bits, signed
  uint8_t w;  // exactly 8 bits, unsigned
  ...
```

Use extended types in most cse333 code

```
void sumstore(int x, int y, int* dest) {
```

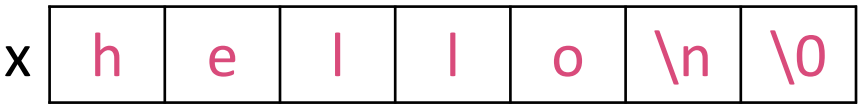
But `int` is usually fine for simple counters

```
void sumstore(int32_t x, int32_t y, int32_t* dest) {
```

Basic Data Structures

- C does not support objects!!!
- **Arrays** are contiguous chunks of memory
  - Arrays have no methods and do not know their own length
  - Can easily run off ends of arrays in C – security bugs!!!
- **Strings** are null-terminated char arrays
  - Strings have no methods, but `string.h` has helpful utilities

```
char* x = "hello\n";
```



- **Structs** are the most object-like feature, but are just collections of fields – no "methods" or functions
  - (but can contain pointers to functions!)

Function Definitions

- Generic format:

```
returnType fname(type param1, …, type paramN) {
    // statements
}
```

```
// sum of integers from 1 to max
int sumTo(int max) {
  int i, sum = 0;

  for (i = 1; i <= max; i++) {
    sum += i;
  }

  return sum;
}
```

Function Ordering

- You *shouldn't* call a function that hasn't been declared yet
- This is because C compilers used to be single-pass

sum_badorder.c

```c
#include <stdio.h>

int main(int argc, char** argv) {
  printf("sumTo(5) is: %d\n", sumTo(5));
  return 0;
}

// sum of integers from 1 to max
int sumTo(int max) {
  int i, sum = 0;

  for (i = 1; i <= max; i++) {
    sum += i;
  }
  return sum;
}
```

Solution 1: Reverse Ordering

- Simple solution; however, imposes ordering restriction on writing functions (who-calls-what?)

sum_betterorder.c

```c
#include <stdio.h>

// sum of integers from 1 to max
int sumTo(int max) {
  int i, sum = 0;

  for (i = 1; i <= max; i++) {
    sum += i;
  }
  return sum;
}

int main(int argc, char** argv) {
  printf("sumTo(5) is: %d\n", sumTo(5));
  return 0;
}
```

Solution 2: Function Declaration

- Teaches the compiler arguments and return types; function definitions can then be in a logical order, and call each other without restriction

sum_declared.c

Code examples from slides are on the course web for you to experiment with!

```c
#include <stdio.h>

int sumTo(int);  // func prototype

int main(int argc, char** argv) {
  printf("sumTo(5) is: %d\n", sumTo(5));
  return 0;
}

// sum of integers from 1 to max
int sumTo(int max) {
  int i, sum = 0;
  for (i = 1; i <= max; i++) {
    sum += i;
  }
  return sum;
}
```

Declaration vs. Definition

- C/C++ make a careful distinction between these two
- Definition: the thing itself
  - *e.g.* code for function, variable definition that creates storage
  - Must be **exactly one** definition of each thing (no duplicates)
- Declaration: description of a thing defined elsewhere
  - *e.g.* function prototype, external variable declaration
    - Often in header files and incorporated via `#include`
    - Should also `#include` declaration in the file with the actual definition to check for consistency
  - Needs to appear in **all files** that use the thing
    - Must appear before first use

Multi-file C Programs

C source file 1 (sumstore.c)

```
void sumstore(int x, int y, int* dest) {
  *dest = x + y;
}
```

definition

C source file 2 (sumnum.c)

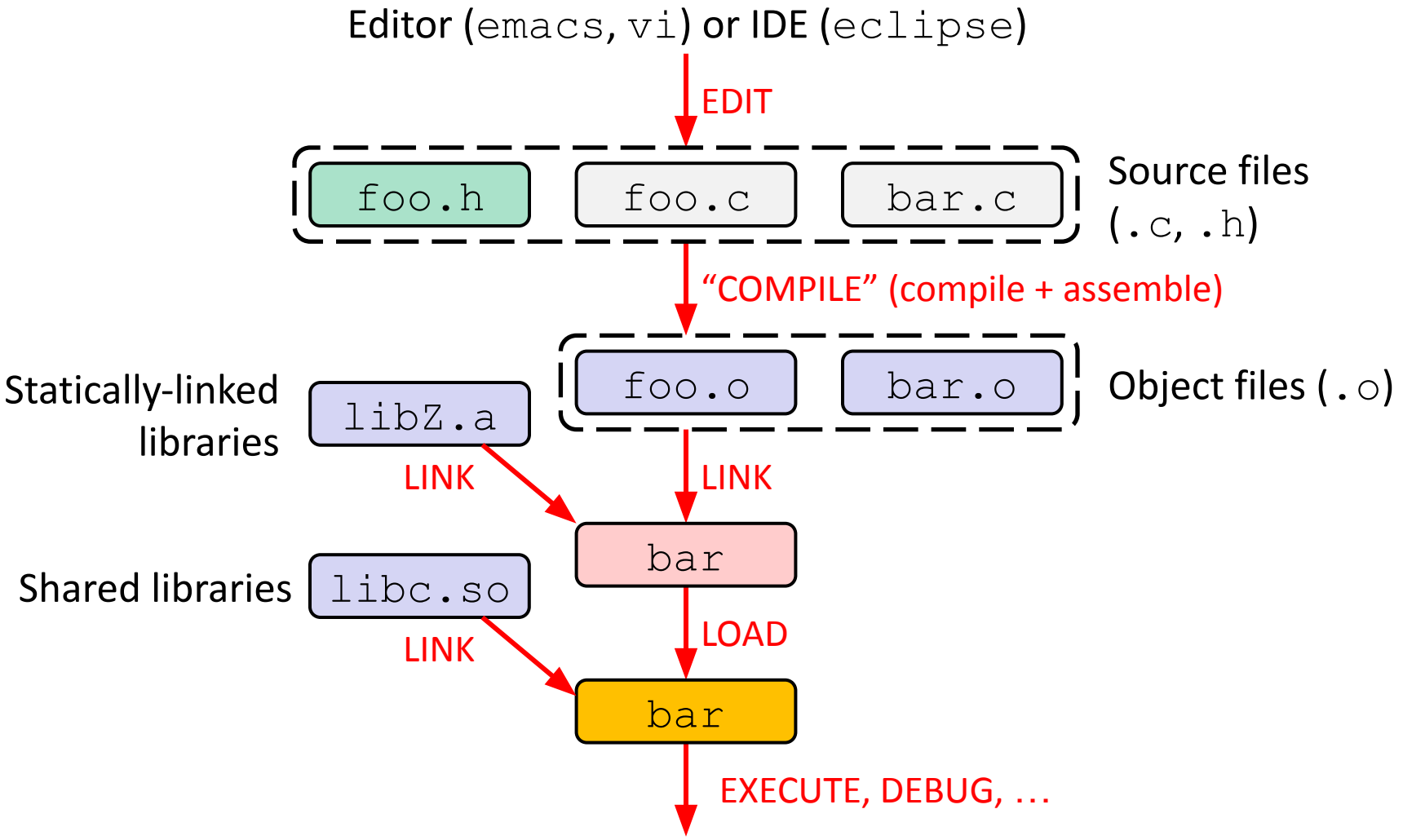
```
#include <stdio.h>

void sumstore(int x, int y, int* dest);

int main(int argc, char** argv) {
  int z, x = 351, y = 333;
  sumstore(x,y,&z);
  printf("%d + %d = %d\n",x,y,z);
  return 0;
}
```

declaration

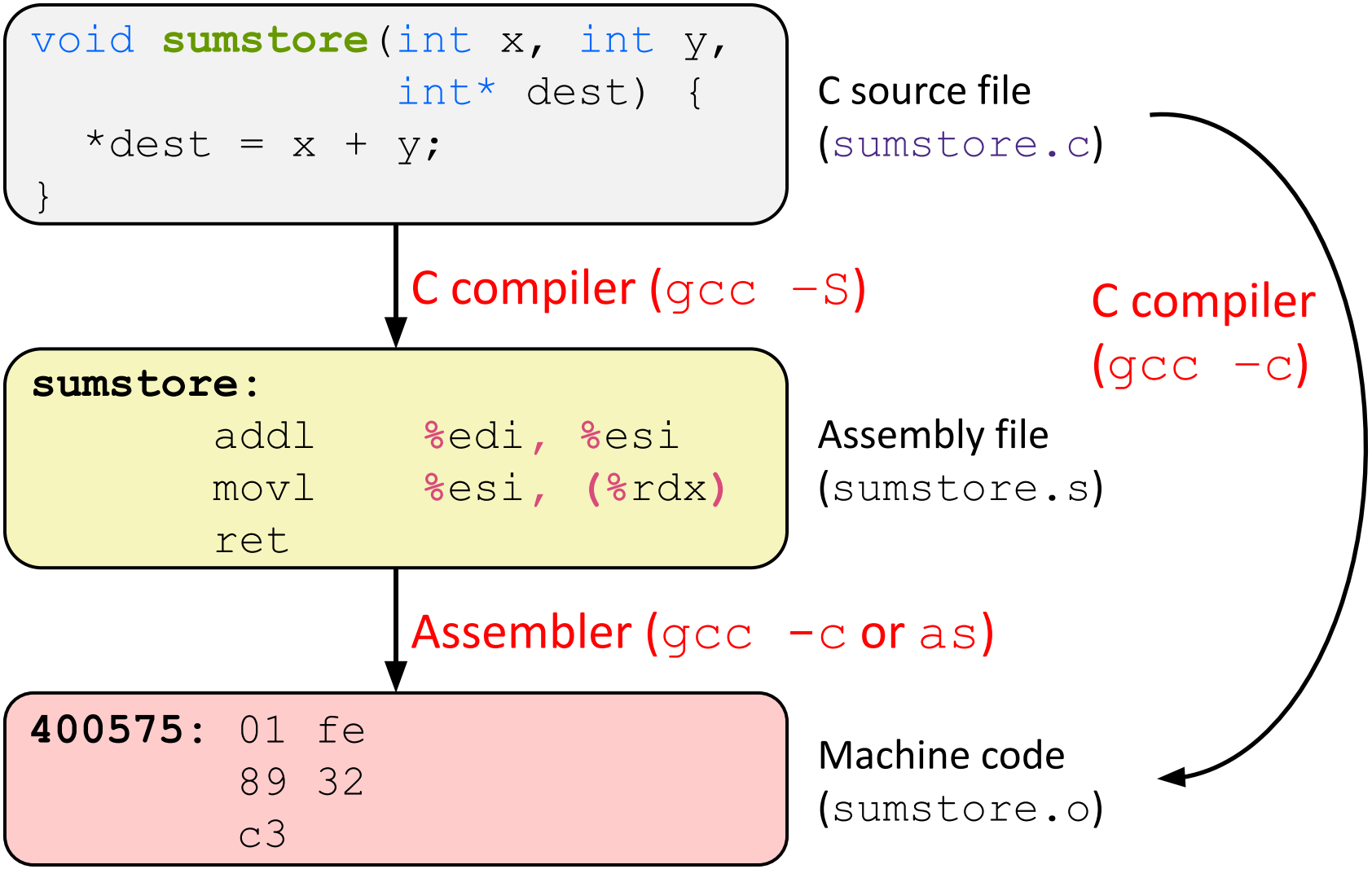
Compile together:

```
$ gcc -o sumnum sumnum.c sumstore.c
```

C Workflow

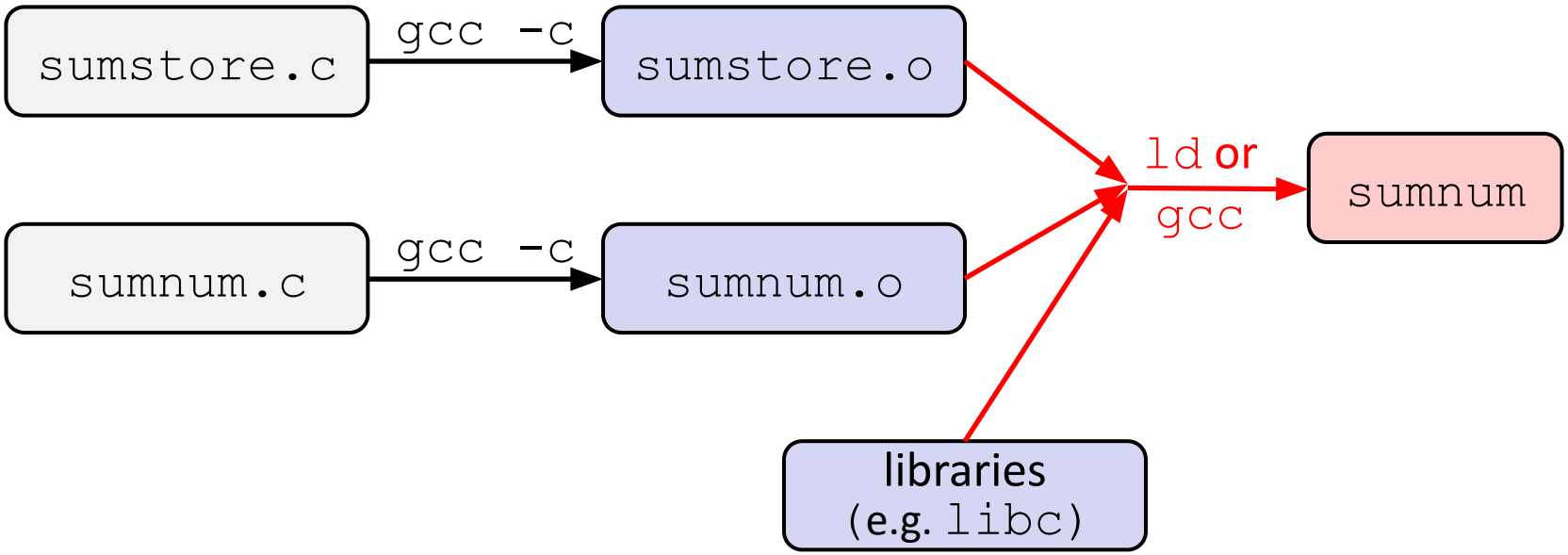

Editor (emacs, vi) or IDE (eclipse)
EDIT
foo.h
foo.c
bar.c
Source files (.c, .h)
"COMPILE" (compile + assemble)
foo.o
bar.o
Object files (.o)
Statically-linked libraries
libZ.a
LINK
LINK
bar
Shared libraries
libc.so
LINK
LOAD
bar
EXECUTE, DEBUG, …

C to Machine Code



Compiling Multi-file Programs

- The **linker** combines multiple object files plus statically-linked libraries to produce an executable
  - Includes many standard libraries (*e.g.* `libc`, `crt1`)
    - A *library* is just a pre-assembled collection of `.o` files



To-do List

- Explore the website *thoroughly*: http://cs.uw.edu/333
- Computer setup: CSE labs, attu, or CSE Linux VM
- Exercise 0 is due 10 am **sharp** on Wednesday
  - Find exercise spec on website, submit via Gradescope
  - Sample solution will be posted later that day
  - Give it your best shot
- Project repos created and hw0 out Wednesday
  - Ask questions on Ed!
  - More questions? Bring them (and your laptop) to section