6.110 Computer Language Engineering

Recitation 1: Project overview/phase 1

February 7, 2025

Before we get started…

We’d appreciate your feedback! Here are some ways to give us feedback:

- Weekly check-in forms
- Piazza posts (can be fully anonymous)

Announcements ←

Weekly updates

Project overview

Phase 1 details

Re-lectures

- Re-lectures will be **Wednesdays 4-6pm**, starting this upcoming Wednesday.
- Re-lectures will be recorded.
- Location TBD, look for an announcement on Piazza by Monday.

Office Hours

https://6110-sp25.github.io/office-hours

- Debugging help not guaranteed — best effort
- Come if you want comments on your design
- Different TAs comfortable w/ different languages
- Rooms TBD, will be posted on Piazza as soon as we get room confirmations
- **Please come to office hours early (not last minute)** — everyone is better off

Fresh off the press

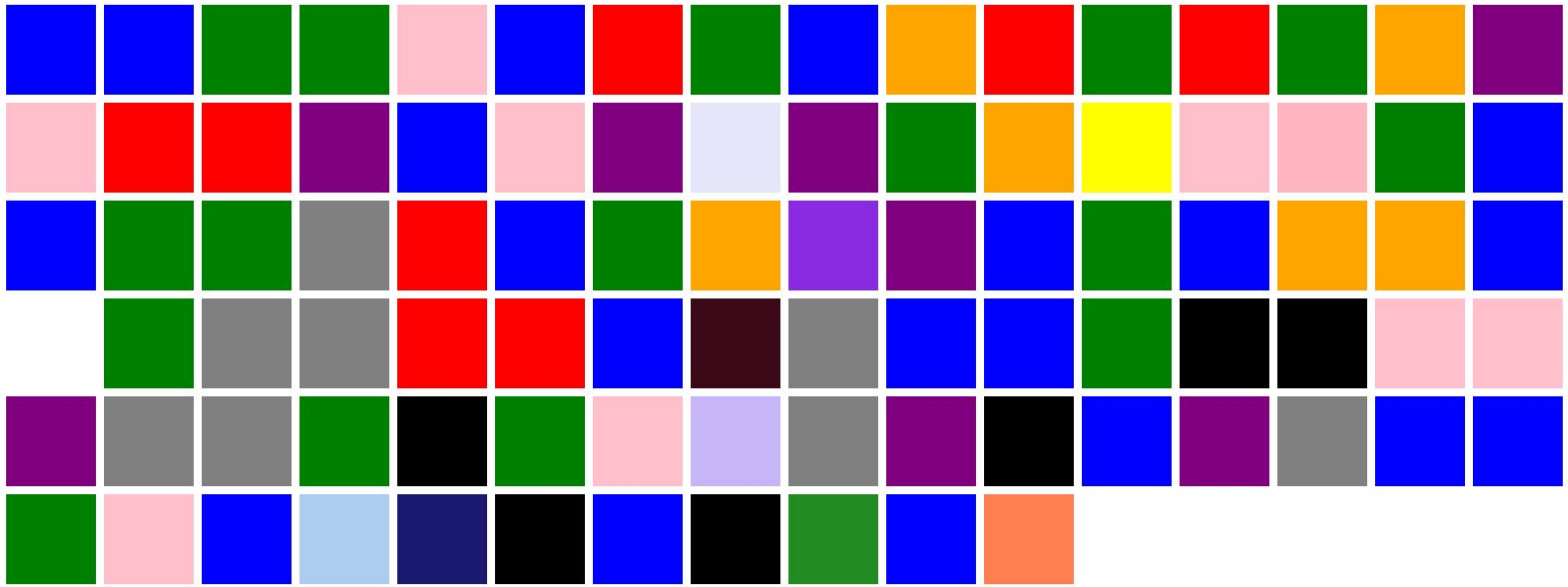
Project phase 1: due **Friday, February 21**

Mini-quiz 1 and Weekly Check-in 2: due **Thursday, February 13**

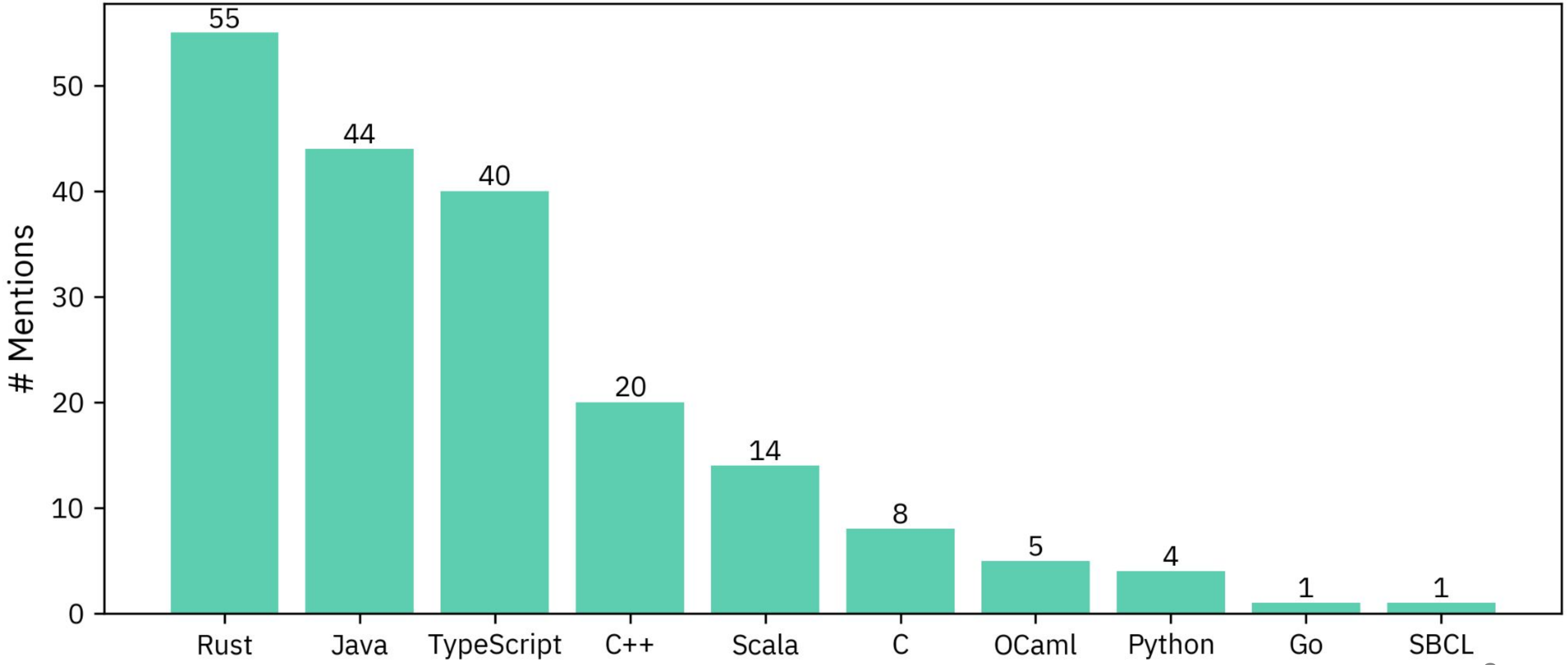
If you haven't submitted Weekly Check-in 1 yet, **please do so ASAP**.

- We need your GitHub account to create your phase 1 repository.
- Future assignments must be submitted on time!

Check-in 1: Colors



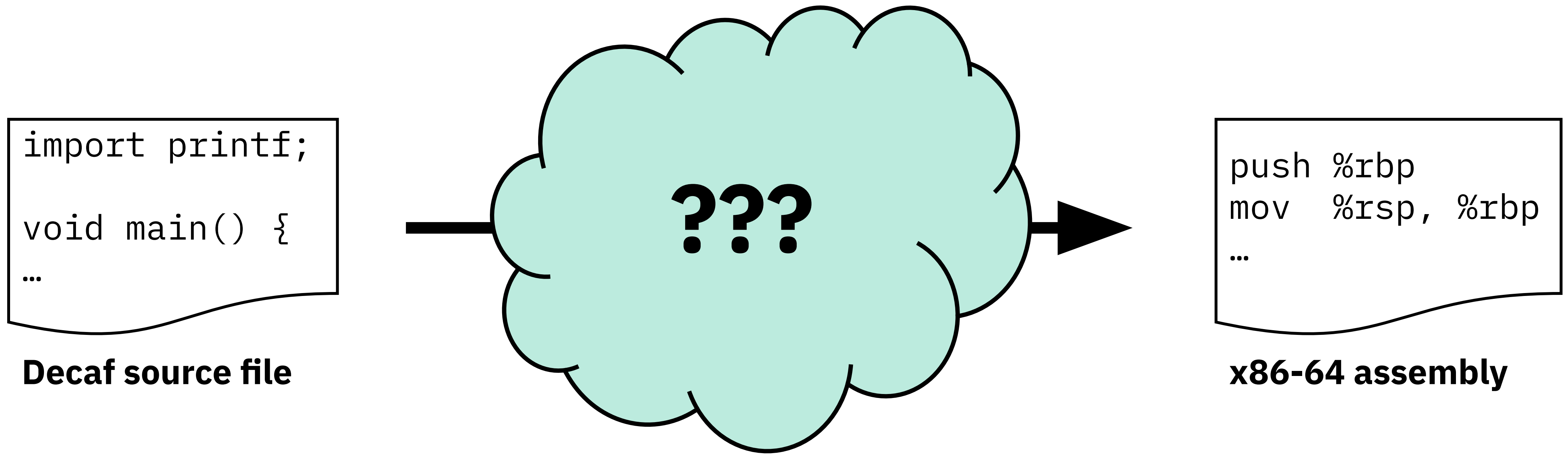
Check-in 1: Languages



Coming up soon... **Week 2**

Mon 2/10	**Tue 2/11**	**Wed 2/12**	**Thu 2/13**	**Fri 2/14**
Lecture Top-down parsing	**Lecture**	**Lecture**	**Lecture**	**Recitation** Scanning and parsing a toy language
		Re-lecture for Week 1 lectures	**Due:** Mini-quiz, weekly check-in	

Project overview



```
import printf;

void main() {
…
```

Decaf source file

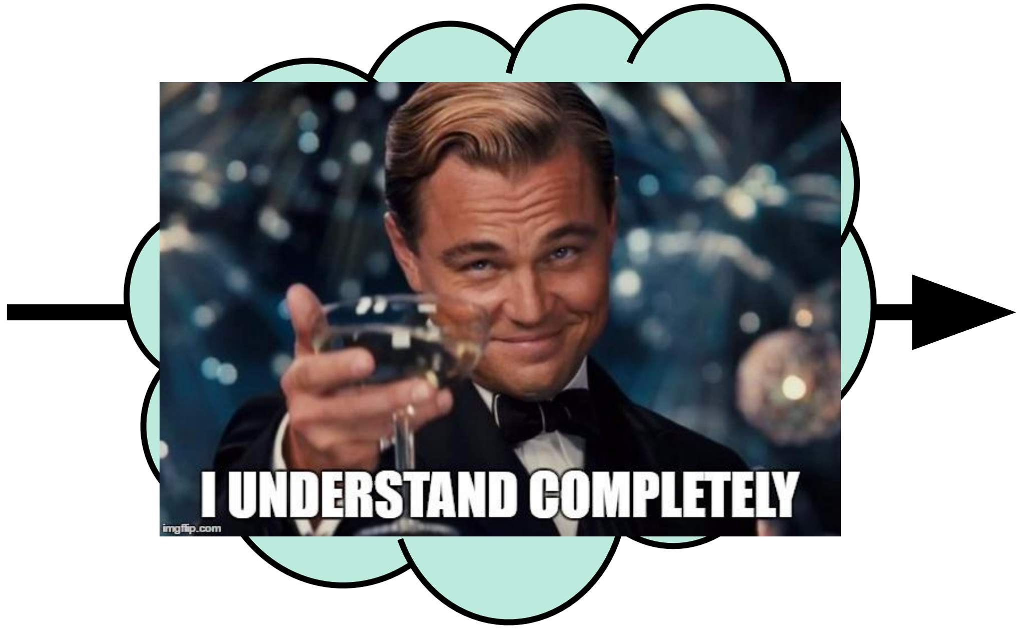
```
push %rbp
mov  %rsp, %rbp
…
```

x86-64 assembly

Project overview

According to
all known laws
of aviation,
there is no…

Language 1



De acuerdo con
todas las leyes
conocidas
de la …

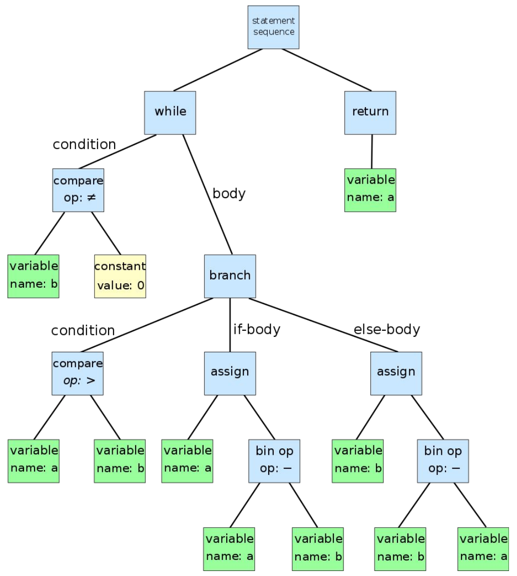
Language 2

Project overview

```
import printf;

void main() {
…
```

Decaf source file



Internal representation

```
push %rbp
mov  %rsp, %rbp
…
```

x86-64 assembly

Project overview

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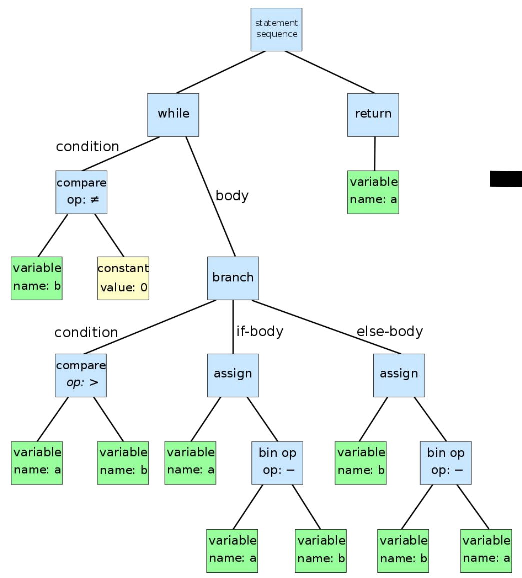

Internal representation

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x86-64 assembly

Phase 1. Does it have the right structure? (syntax)

Phase 2. Does it make sense? (semantics)

Project overview

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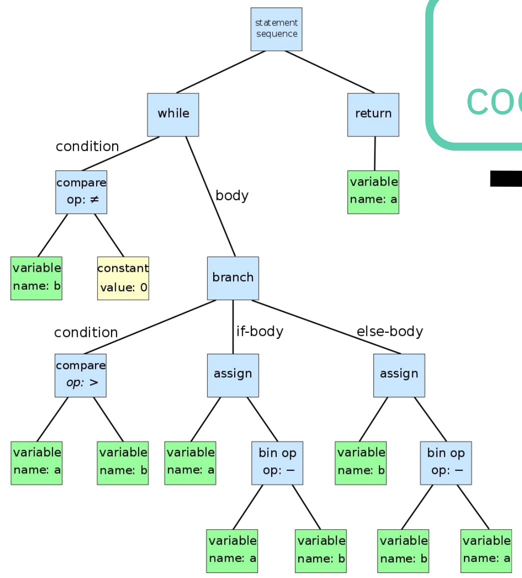
Decaf source file



Internal representation

Phase 3
code generation

```
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mov  %rsp, %rbp
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x86-64 assembly

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Project overview

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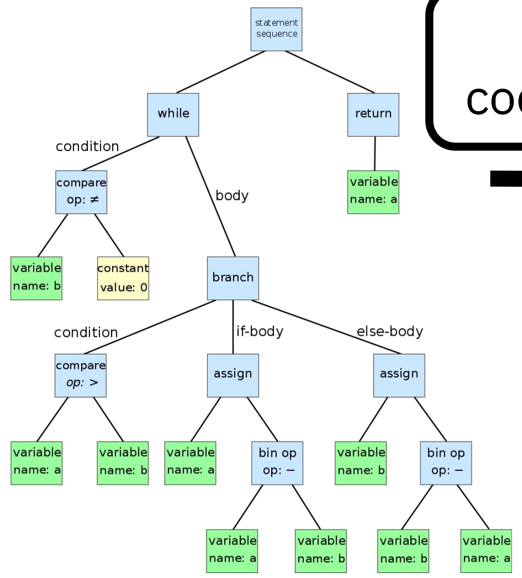
Decaf source file



Internal representation

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x86-64 assembly

Phase 1. Does it have the right structure? (syntax)

Phase 2. Does it make sense? (semantics)

Phase 4. What can we learn about the program? (dataflow analysis)

Project overview

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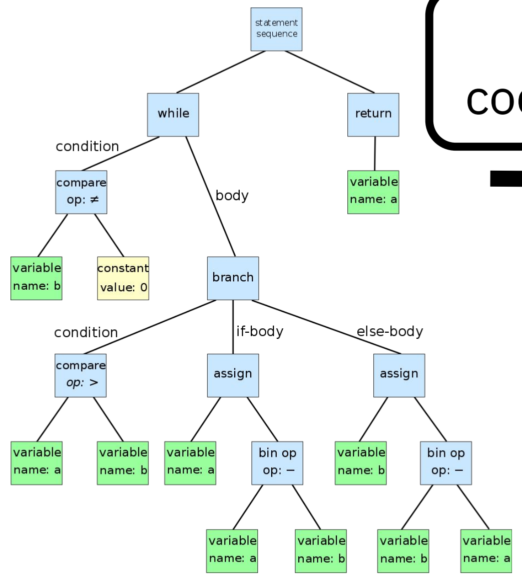
Decaf source file



Internal representation

Phase 3
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x86-64 assembly

Phase 1. Does it have the right structure? (syntax)

Phase 2. Does it make sense? (semantics)

Phase 4. What can we learn about the program? (dataflow analysis)

Phase 5. How can we make the output code faster?

Things we specify for you:

- Input language (Decaf)
- Output language (x86-64 assembly)
- General design (scanning → parsing → semantic checking → code generation)
- Command line interface

Features of Decaf

- Imperative language, watered down version of C — name stands for Decaffeinated C.
- Follows C semantics and calling convention.
- Types: **`int`**, **`long`**, **`bool`**.
- Operations (arithmetic / boolean / comparison)
- Constant-sized arrays
- Functions

Example Decaf program

```
import printf;
int array[100];
void main() {
    int i, sum;
    sum = 0;
    for (i = 0; i < len(array); i++) {
        sum += i;
    }
    printf("%d\n", sum);
}
```

Command line interface

- `./build.sh` builds your compiler
- `./run.sh filename [options]` runs your compiler, must support the following options:

`-t | --target <stage>`	Specify compilation stage: **`scan`**, **`parse`**, **`inter`**, or **`assembly`**
`-o | --output <outname>`	Write output to the specified file name. (If blank, output to stdout)
`-O | --opt [optimizations,…]`	Perform the listed optimizations. **`all`** means all optimizations, **`-optname`** removes optname.
`-d | --debug`	Prints debug information

Announcements

Weekly updates

Project overview

Phase 1 details ←

Phase 1 overview

Goal: have a working program that can determine whether each input Decaf code is *syntactically* valid or not.

- We split this into two subtasks: **scanning** and **parsing.**
- What this phase *doesn't* cover: semantics. Things like type checking, bounds checking, etc. will be done in the next phase.

Scanner

Input: Decaf code, essentially a string

Output: A list of tokens

Example:

```
print("Hello, World!");   →  ▪ print
                              ▪ (
                              ▪ "Hello, World!"
                              ▪ )
                              ▪ ;
```

Scanner specifications

When running `./run.sh <filename> -t scan` on **a lexically valid input file:**

- Exit with return code 0 (OK)
- Outputs tokens, one per line.
- For identifiers and literals, also output the token type:

```
IDENTIFIER print
(
STRINGLITERAL "Hello, World!"
)
;
```

Scanner specifications

When running `./run.sh <filename> -t scan` on **a lexically invalid input file:**

- Exit with a nonzero return code (i.e. error)

The autograder doesn’t check the output, but it’s nice to output an error message.

Parser

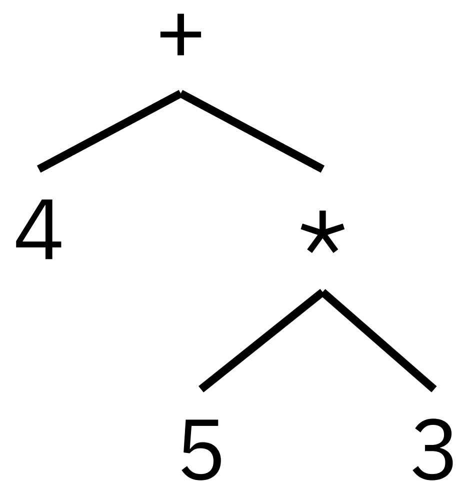
Input: A list of tokens

Output: A *parse tree*, which is a data structure that encapsulates the syntactic structure of the program

Example:

```
INTLITERAL 4
+
INTLITERAL 5
*
INTLITERAL 3
```

$\rightarrow$



Parser specifications

When running `./run.sh <filename> -t scan` on **a syntactically valid input file:**

- Exits with return code 0 (OK)
- Produce no output

You can decide how you want to implement your parse trees

Parser specifications

When running `./run.sh <filename> -t scan` on **a syntactically invalid input file:**

- Exit with nonzero return code (i.e. error)

Again, the autograder doesn’t check the output, but it’s nice to output an error message.

Submission and grading

Phase 1 is worth **5%** of the overall grade, due **Friday, February 21.**

Three items to be submitted on Gradescope

- Code submission (autograded)
  - Scanner tests: **2%**
  - Parser tests: **2%**
- Short report (1-2 paragraphs): **1%** (due 1 day after deadline so that you can focus on code up to the end)
- LLM questionnaire: **0%** (due 3 days after deadline)

Getting started

- You should have received an invite to join the course organization (`6110-sp25`).
- We created a repo `<your-kerb>-phase1` for you.
  - If you don't have access to it, let us know ASAP.
- Make sure to accept the invite for both the organization and the repo!

Getting started

- We have starting skeletons for Java, Scala, Rust, and Typescript.
  - The skeletons come with a build system and a barebones implementation of the CLI.
  - To use the skeletons, follow the instructions on the Project Skeletons page on the course website.
- You're also welcome to start from scratch if you'd like to use a different build system or language (but let us know so we can support it on the autograder!)

Testing

Unit tests: the skeletons come with unit-testing frameworks. (ex. Mocha for Typescript)

- It's good practice to write your own unit tests for each function/module you're writing. The scanner/parser can get pretty complex, and the test cases we provide are only end-to-end.

End-to-end tests: we provide public test cases in the `public-tests` repository.

- You should write your own script to run these tests

Testing

You can also submit your code on Gradescope to see feedback on the tests (you'll see the test names and whether you passed or failed them).

- We suggest doing this if you edit `./build.sh` or `./run.sh` to verify that the autograder can successfully build your code.
- There is no rate limit, but **try not to overuse this.**
- Try to use this only for verification purposes, and don't submit every single commit, for example.
- Don't blindly try to increase your # of private tests passed.

Words of advice

Start early!

- The project deadlines in this class are spaced out, so it’s easy to feel like you have a lot of time … until you don’t.

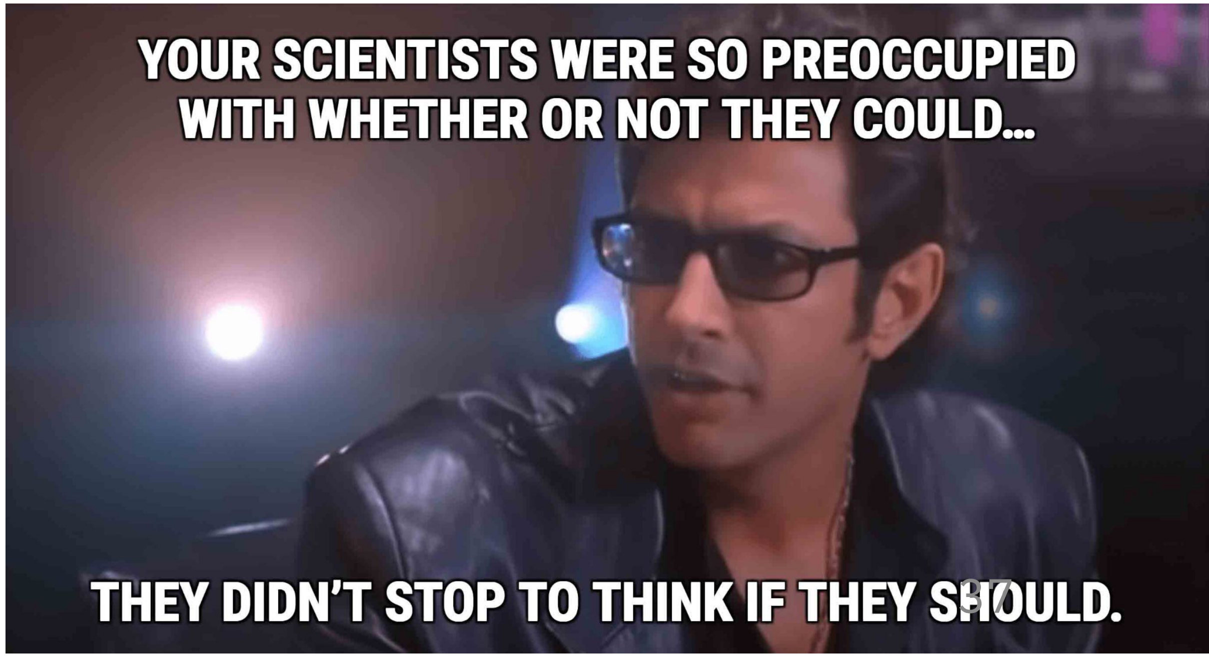
You’ll face a lot of design decisions.

- E.g.: do you want to use the same token data types for both the scanner output and the parse tree?
- A lot of of the time, it’s usually okay either way. But if you made a choice and got really stuck, maybe step back and reconsider design choices.

About languages

"Can we use X language for our compilers?"

- **YES**! As long as it conforms to the command line interface
- **BUT**—
    - Real-life engineering isn't about using the coolest language


YOUR SCIENTISTS WERE SO PREOCCUPIED WITH WHETHER OR NOT THEY COULD...
THEY DIDN'T STOP TO THINK IF THEY SHOULD.

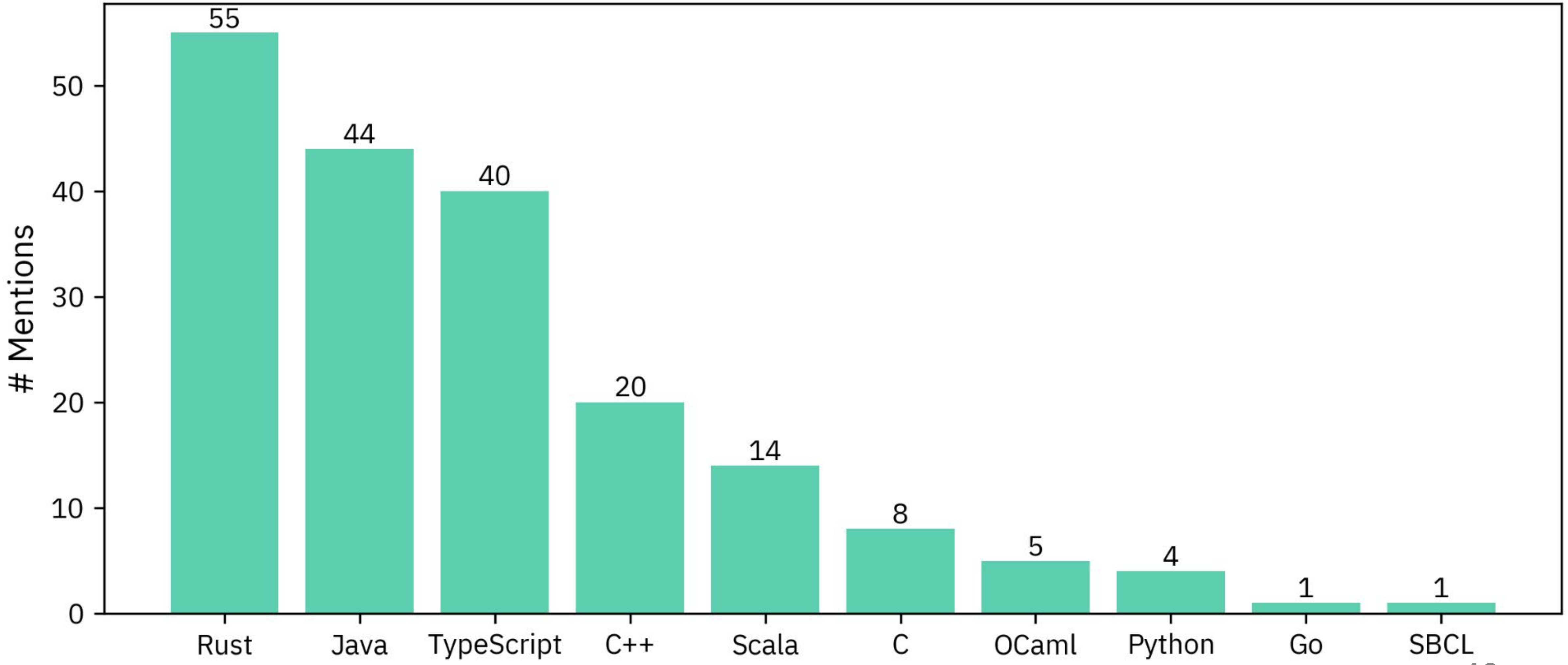
Non-technical considerations

- Are your team all onboard?
- Are TAs familiar with it?
    - TAs only officially support Rust, Java, Scala & TypeScript
- *Are LLMs familiar with it?

Technical considerations

- Strong type system is good
- Memory safety is a plus
    - We **strongly advise against** C/C++
- Abstraction power
- Style consistency
- Hackability*
- Performance is *not that important*
- Don’t be religious; be pragmatic

Check-in 1: Languages



Words of advice

Start with a subset of the Decaf grammar.

- Dealing with the whole grammar at once can be intimidating. Try picking a self-contained subset of it (ex. arithmetic expressions only, or pure expressions only)

Keep source location information.

- While we don’t require this in Phase 1, this will be required in the next phase, and it’ll also make debugging a lot easier.

Words of advice

Consider using existing libraries to help.

- Regex libraries are allowed and very helpful for scanning.
- If you're interested, also check out scanner/parser generators. Our general advice is use these if you already knew the language well, it might be a good learning experience to use them.
  - Examples: ANTLR, tree-sitter, Pest, etc.
- If you are not familiar with the language, we strongly recommend **handwriting the parser** to gain concrete experience

Words of advice

The course staff is here to help!

- Come to office hours or ask on Piazza!
- We know that this project can feel pretty intimidating.
- We can give you suggestions on how to start, and we will try to help you debug issues with your parser and scanner.
- (Note that we give you a lot of freedom on how to approach the project, and so we might not be able to give very specific guidance in some cases.)