Lecture 1: Hello World!

Yu Feng
Fall 2021

Introducing the cast

Instructor: Yu Feng   yufeng@cs.ucsb.edu

Course website: https://github.com/fredfeng/CS160

Research areas: programming languages, program analysis,
                 program synthesis, and security

Website: http://fredfeng.github.io/

Office hour: Mon 3pm-4pm (HFH-2157)

Q&A: https://tinyurl.com/54n78wdx

Introducing the cast

TA: Junrui Liu (bryantan@ucsb.edu)
Peter Boyland (boyland@umail.ucsb.edu)

Office hour: See web page

Discussion session: See web page

What can we learn

You will learn:

- Functional programming in OCaml

- Lexing/Parsing/Interpreters

- How high-level languages are implemented in machine language

- A little about programming language semantics & types

- build a compiler (Patina) from scratch

- A deeper understanding of code: a better programmer

https://junrui-liu.github.io/patina/

What is a compiler

- A compiler is a program that translates from one programming language to another

- High-level source code to low-level machine code
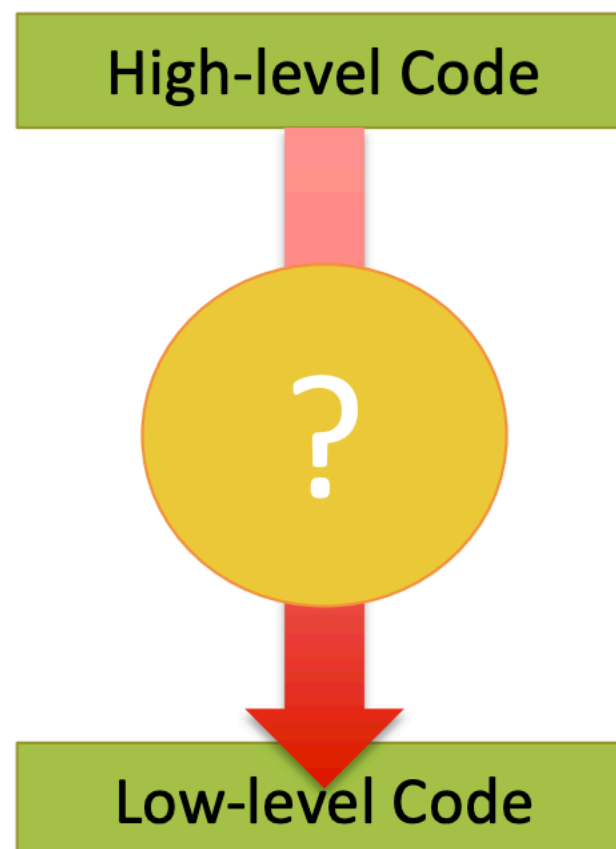
History of compilers

What is the first language?

- Until the 1950's: computers were programmed in assembly.

- 1951—1952: Grace Hopper

– developed the A-0 system for the UNIVAC I

– Contributed significantly to the design of COBOL

- 1957: FORTRAN compiler built at IBM

- 1960's: development of the first bootstrapping compiler for LISP

- Today: thousands of languages (most little used)

Source Code

- Optimized for human readability

  - Expressive: matches human ideas of grammar / syntax / meaning

  - Redundant: more information than needed to help catch errors

  - Abstract: data structures, design patterns, etc.

```c
#include <stdio.h>

int factorial(int n) {
  int acc = 1;
  while (n > 0) {
    acc = acc * n;
    n = n - 1;
  }
  return acc;
}

int main(int argc, char *argv[]) {
  printf("factorial(6) = %d\n", factorial(6));
}
```

Machine Code

- Optimized for Hardware

  - Machine code hard for people to read

  - Reduce redundancy & ambiguity

  - Abstractions & information about intent is lost

  - Assembly language — then machine language
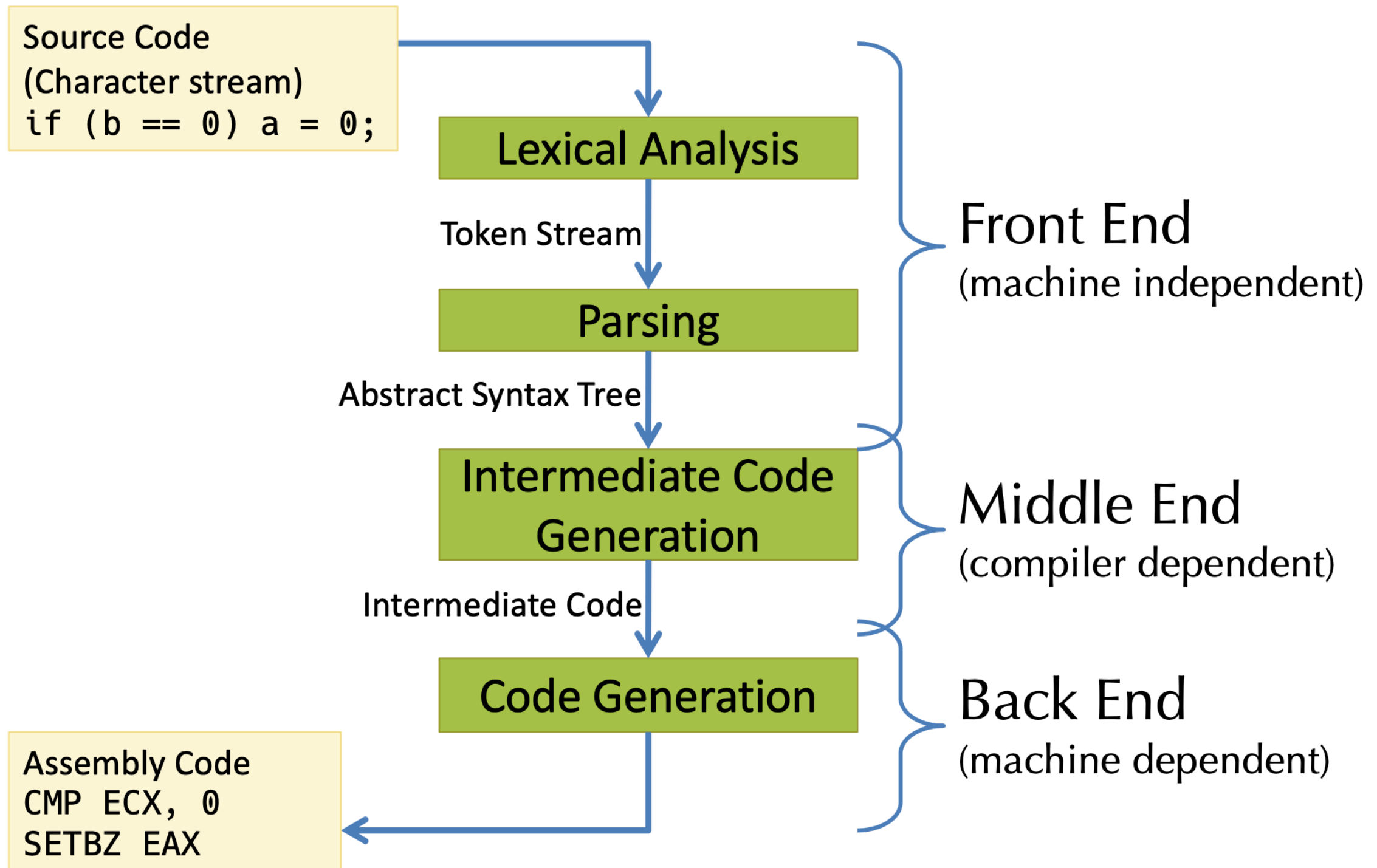
```
_factorial:
## BB#0:
    pushl   %ebp
    movl    %esp, %ebp
    subl    $8, %esp
    movl    8(%ebp), %eax
    movl    %eax, -4(%ebp)
    movl    $1, -8(%ebp)
LBB0_1:
    cmpl    $0, -4(%ebp)
    jle     LBB0_3
## BB#2:
    movl    -8(%ebp), %eax
    imull   -4(%ebp), %eax
    movl    %eax, -8(%ebp)
    movl    -4(%ebp), %eax
    subl    $1, %eax
    movl    %eax, -4(%ebp)
    jmp     LBB0_1
LBB0_3:
    movl    -8(%ebp), %eax
    addl    $8, %esp
    popl    %ebp
    retl
```
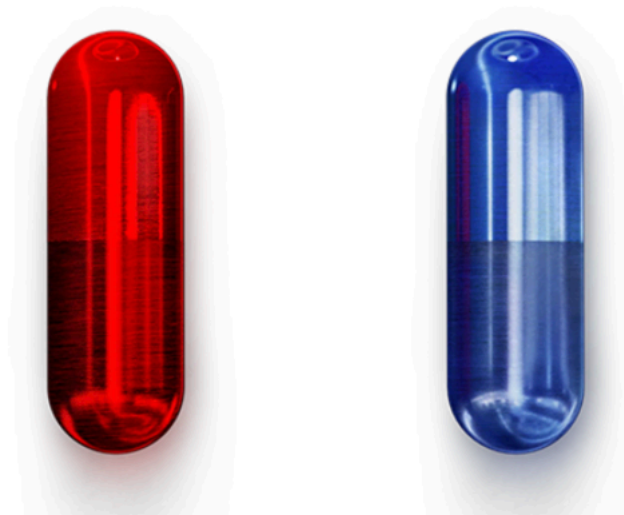
How to translate

- Mismatch between source code and machine code

- Some languages are farther from machine code than others: C++, Java, Lisp, ML, Haskell, Ruby, Python, Javascript…

- Goals of translation:

  - Source level expressiveness for the task

  - Best performance for the concrete computation

  - Reasonable translation efficiency

  - Maintainable code – Correctness!

Compiler Structure

Source Code
(Character stream)
`if (b == 0) a = 0;`

Lexical Analysis

Token Stream

Parsing

Abstract Syntax Tree

Intermediate Code
Generation

Intermediate Code

Code Generation

Assembly Code
`CMP ECX, 0`
`SETBZ EAX`

Front End
(machine independent)

Middle End
(compiler dependent)

Back End
(machine dependent)

Red or Blue

Safety

- Maintain social distance

- Mask is required indoor

- I will bring extra masks in case you need them

FACE MASKS REQUIRED

PRIOR TO ENTRY

Grading

- Programming assignments: 80%

  - 5 (PA1-PA5) programming assignments, 16% each

- Take-home midterm (open book): 20%

Programming assignments

- Please check the website regularly

- Deadline extension:

  - Ten "late days"

  - Plan ahead, no other extensions

Programming assignments
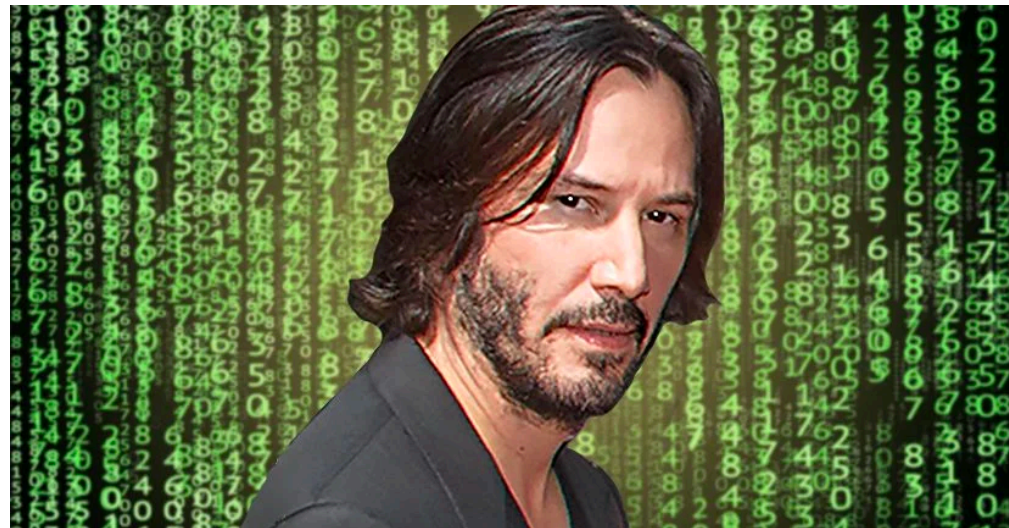
Unfamiliar languages

+ Unfamiliar environments
_____

Start early!

OCaml is hard

+ Racket is @!#@%
_____

Start early!

Free your mind

Academic integrity

- All assignments should be done ALONE

- We use MOSS to detect plagiarism

  - Have code from public repos

  - Make sure your repo private

- "F" if you violate the honor code

TODOs by next lecture

- Join Slack for CS160!

- Install/try OCaml on your laptop

- Get familiar with your new friend: Patina manual