CS 160 Compilers

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 (junrui@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:

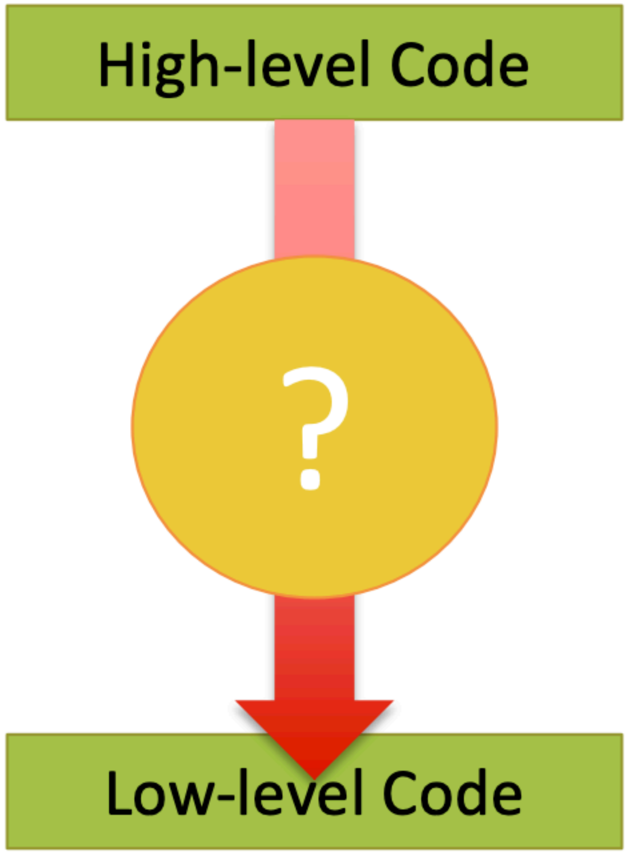
- Functional programming in OCaml
- Lexing/Parsing/Interpreters
- How high-level languages are implemented in machine language
- A little about programming language semantics & types
- build a compiler (Patina) from scratch
- A deeper understanding of code: a better programmer

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

Why do we need compiler?

  - Expressive: matches human ideas of grammar / syntax / meaning
  - Redundant: more information than needed to help catch errors
  - Abstract: data structures, design patterns, etc.

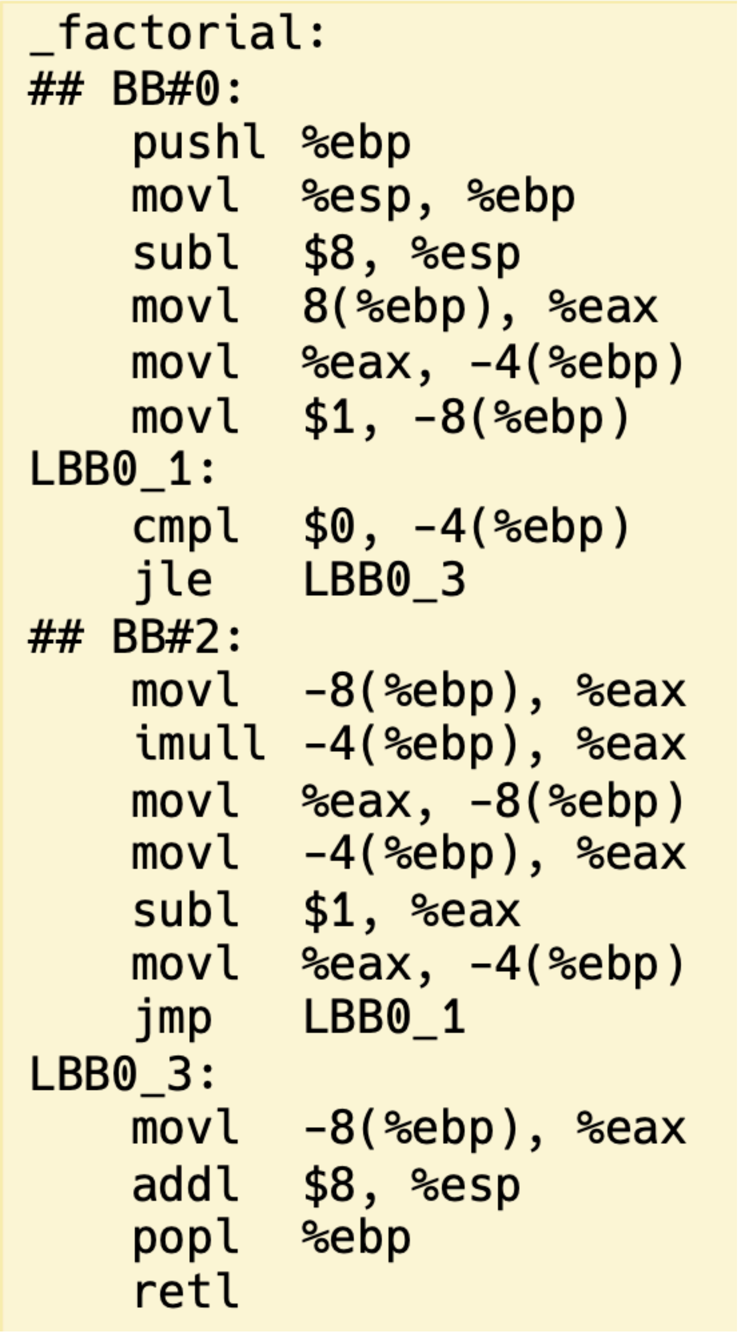
```
#include <stdio.h>

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

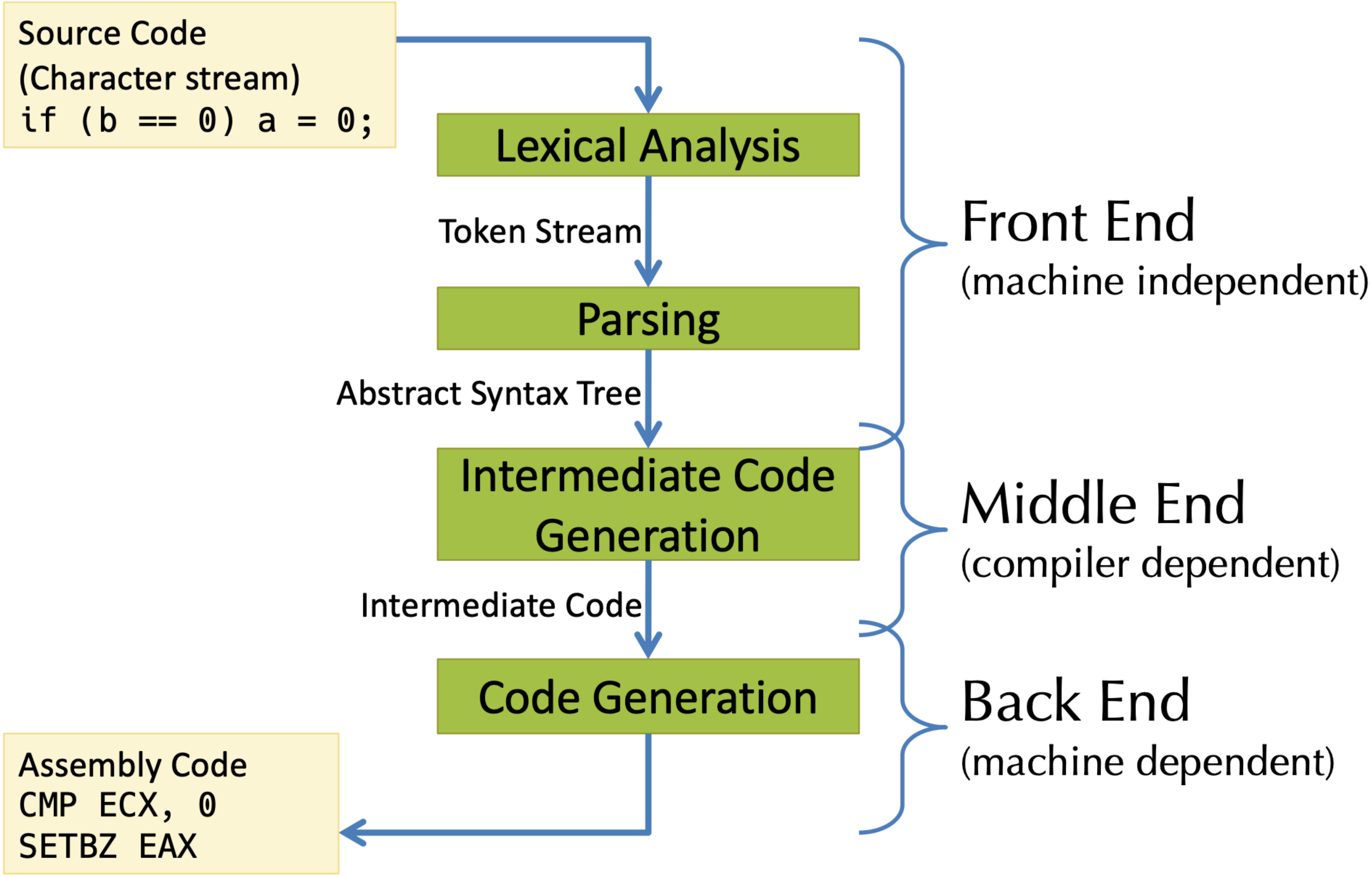


```
_factorial:
## BB#0:
    pushl %ebp
    movl  %esp, %ebp
    subl  $8, %esp
    movl  8(%ebp), %eax
    movl  %eax, -4(%ebp)
    movl  $1, -8(%ebp)
LBB0_1:
    cmpl  $0, -4(%ebp)
    jle   LBB0_3
## BB#2:
    movl  -8(%ebp), %eax
    imull -4(%ebp), %eax
    movl  %eax, -8(%ebp)
    movl  -4(%ebp), %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
```

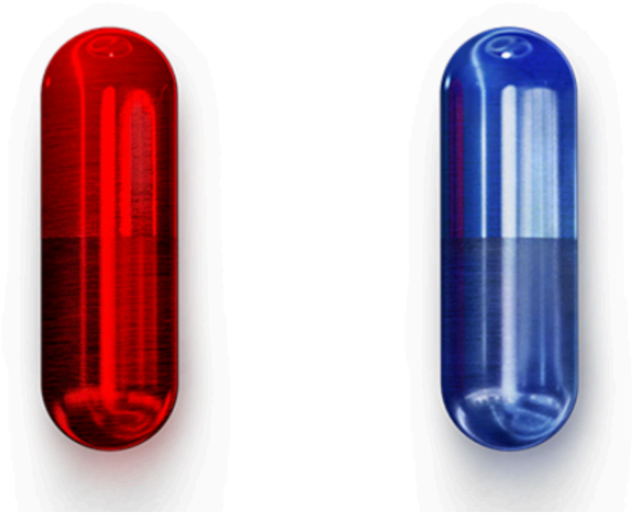
Front End
(machine independent)

Middle End
(compiler dependent)

Back End
(machine dependent)

Red or Blue

THE CHOICE IS YOURS



Safety

- Maintain social distance
- Mask is required indoor
- I will bring extra masks in case you need them

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

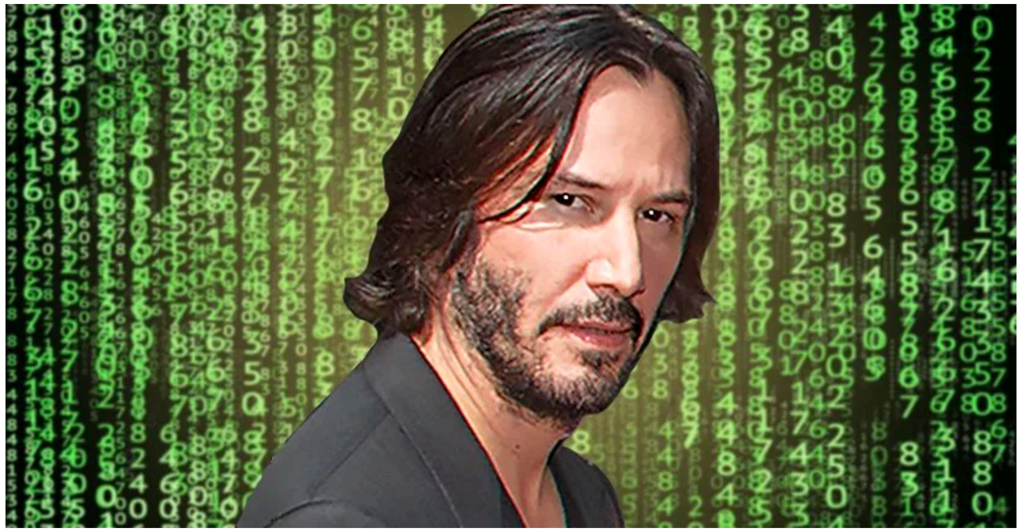
+ Unfamiliar environments

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