C and Compilation

CS 2130: Computer Systems and Organization 1

March 22, 2023

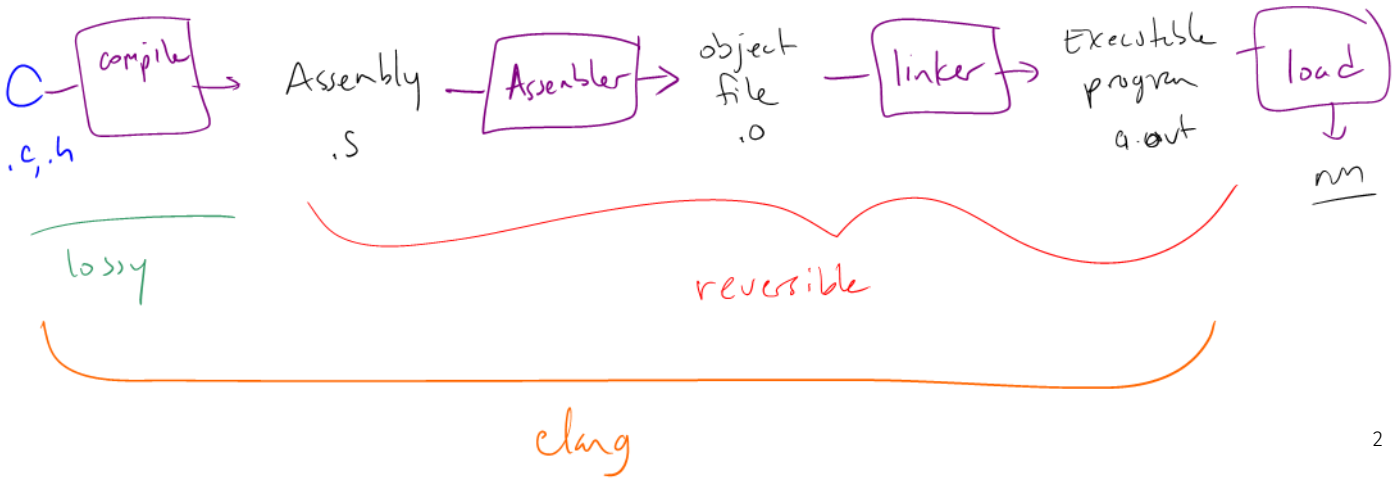
Announcements

- Homework 6 Escape Room due Monday at 11pm

Compilation Pipeline

Turning our code into something that runs

- **Pipeline** - a sequence of steps in which each builds off the last



Why did we discuss assembly?

C

C is a thin wrapper around assembly

- This is by design!
- Invented to write an operating system
  - Can write inline assembly in C
- Many other languages decided to look like C

Simple C Example

```
int main() {
    int y = 5;
    return 0;
}
```

Compilation Pipeline

Earlier, we saw:

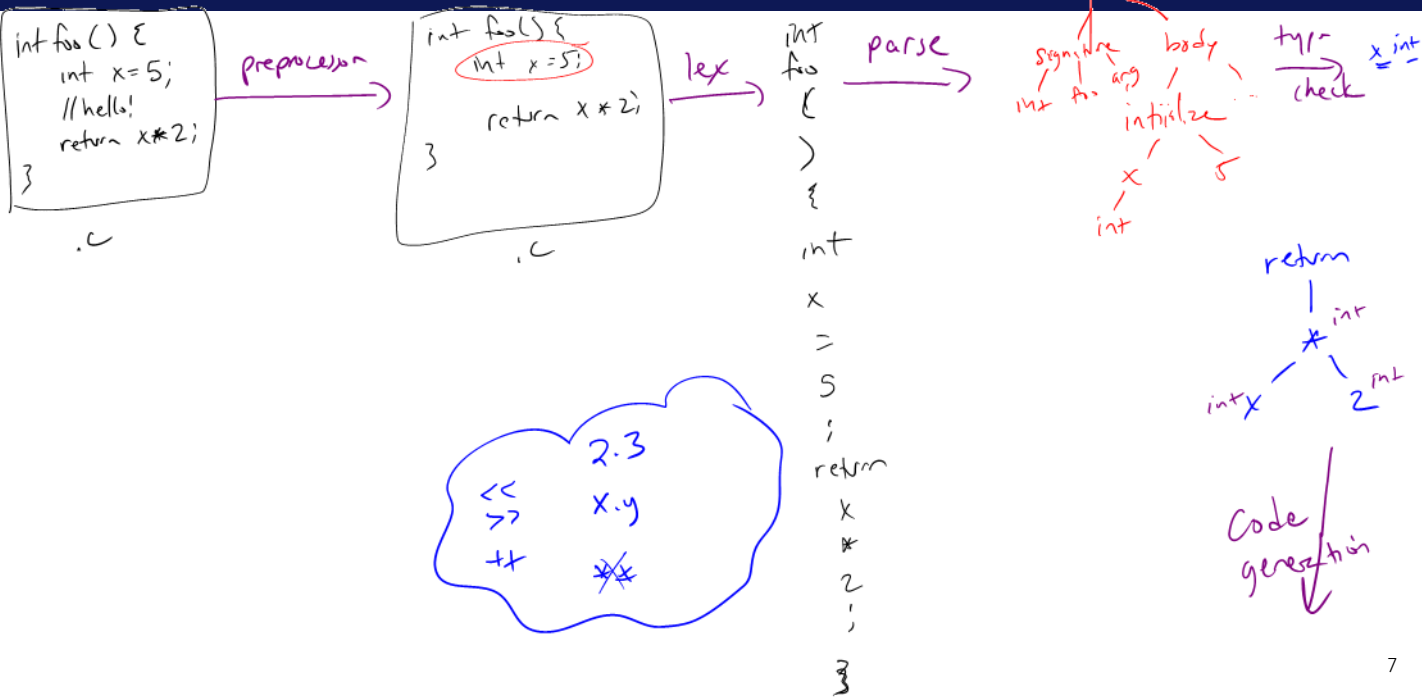
- C files (`.c`) compiled to assembly (`.s`)
- Assembly (`.s`) assembled into object files (`.o`)
- Object files (`.o`) linked into a program / executable

Compiling C to Assembly

Multiple stages to compile C to assembly

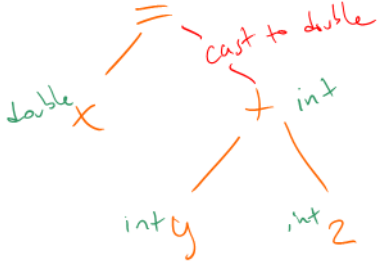
- Preprocess - produces C
  - C is actually implemented as 2 languages:
    C preprocessor language, C language
  - Removes comments, handles preprocessor directives (`#`)
  - `#include`, `#define`, `#if`, `#else`, ...
- Lex - breaks input into individual tokens
- Parse - assembles tokens into intended meaning (parse tree)
- Type check - ensures types match, adds casting as needed
- Code generation - creates assembly from parse tree

Compiling C to Assembly



Compiling C to Assembly

```
double x;
int y = 24;
x = y + 2;
```



Errors

Compile-time errors

- Errors we can catch during compilation (this process)
- **Before** running our program

Runtime errors

- Errors that occur when running our programs

Simple C Example

```
int main() {
    return 0;
}
```

The `main` function

- Start running the `main()` function
- `main` must return an integer - **exit code**
  - `0` = everything went okay
  - Anything else = something went wrong
- There *should* be arguments to main

Example

Data Types in C

Integer data types

Data type	Size
char	
short	
int	
long	
long long	

Each has 2 versions: *signed* and *unsigned*

Data Types in C

Floating point

- float
- double

Data Types in C

Data Types in C

Pointers - how C uses addresses!

Data Types in C

Pointers - how C uses addresses!

- Hold the address of a position in memory
- Need to know the kind of information stored at that location

Example

```
int main() {
    int x = 3;
    long y = 4;
    int *a = &x;
    long *b = &y;
    long z = *a;
    int w = *b;
    return 0;
}
```

Example

```
int main() {
    int x = 3;
    long y = 4;
    int *a = &x;
    long *b = &y;
    long z = *a;
    int w = *b;
    return 0;
}
```

```
0000000000000000 <main>:
   0:   55                      push   %rbp
   1:   48 89 e5                mov    %rsp,%rbp
   4:   31 c0                   xor    %eax,%eax
   6:   c7 45 fc 00 00 00 00    movl   $0x0,-0x4(%rbp)
   d:   c7 45 f8 03 00 00 00    movl   $0x3,-0x8(%rbp)
  14:   48 c7 45 f0 04 00 00    movq   $0x4,-0x10(%rbp)
  1b:   00
  1c:   48 8d 4d f8             lea    -0x8(%rbp),%rcx
  20:   48 89 4d e8             mov    %rcx,-0x18(%rbp)
  24:   48 8d 4d f0             lea    -0x10(%rbp),%rcx
  28:   48 89 4d e0             mov    %rcx,-0x20(%rbp)
  2c:   48 8b 4d e8             mov    -0x18(%rbp),%rcx
  30:   48 63 09                movslq (%rcx),%rcx
  33:   48 89 4d d8             mov    %rcx,-0x28(%rbp)
  37:   48 8b 4d e0             mov    -0x20(%rbp),%rcx
  3b:   48 8b 09                mov    (%rcx),%rcx
  3e:   89 4d d4                mov    %ecx,-0x2c(%rbp)
  41:   5d                      pop    %rbp
  42:   c3                      retq
```