Patents and Copyright Compilation Pipeline

CS 2130: Computer Systems and Organization 1
March 16, 2026

Announcements

- Homework 5 **due tonight at 11:59pm** on Gradescope
- Homework 6 coming **tomorrow** during lab **due next Monday**

Functions

```
f(x,y):
    ...
    ...
    return 4



...
z = f(2,5)
```

Function Calls: Calling Conventions

`callq myfun`

- Push return address, then jump to myfun
- Convention: Store arguments in registers and stack before call
  - First 6 arguments (in order): `rdi`, `rsi`, `rdx`, `rcx`, `r8`, `r9`
  - If more arguments, pushed onto stack (last to first)

`retq`

- Pop return address from stack and jump back
- Convention: store return value in `rax` before calling `retq`

This is similar to our Toy ISA's function calls in homework 4

Calling Conventions: Registers

Calling conventions - recommendations for making function calls

- Where to put arguments/parameters for the function call?
- Where to put return value? in `rax` before calling `retq`
- What happens to values in the registers?
  - **Callee-save** - The function should ensure the values in these registers are unchanged when the function returns
    - `rbx`, `rsp`, `rbp`, `r12`, `r13`, `r14`, `r15`
  - **Caller-save** - Before making a function call, save the value, since the function may change it

The Stack

```
pushq %rax
popq %rdx
```

The Stack

`stack.s` – Example with lldb

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

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

Patents and Copyright

Remember our Toy ISA. Can we patent our ISA? Should we?

icode	b	meaning
0		`rA = rB`
1		`rA &= rB`
2		`rA += rB`
3	0	`rA = ~rA`
	1	`rA = !rA`
	2	`rA = -rA`
	3	`rA = pc`
4		`rA` = read from memory at address `rB`
5		write `rA` to memory at address `rB`
6	0	`rA` = read from memory at `pc + 1`
	1	`rA` &= read from memory at `pc + 1`
	2	`rA` += read from memory at `pc + 1`
	3	`rA` = read from memory at the address stored at `pc + 1`
		For icode 6, increase `pc` by 2 at end of instruction
7		Compare `rA` as 8-bit 2's-complement to 0
		if `rA <= 0` set `pc = rB`
		else increment `pc` as normal

Patents and Copyright

Copyright

- “Everyone is a copyright owner. Once you create an original work and fix it, like taking a photograph, writing a poem or blog, or recording a new song, you are the author and the owner.”

from https://www.copyright.gov/what-is-copyright/

Patents and Copyright

Patent

- "Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title."

from 35 U.S.C. 101

Patents

In software and hardware, patents become messy

- Code is a description of a process we want the computer to do
- Do not have to implement the process to patent it

Question: Should we patent something like our ISA?

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Question: Should we patent something like our ISA?

What is the current state of the art?

Common Approaches to Software

How can we get value from what we create?

- Copyright - distribute closed source software
- License Agreements (in contract law)
- Always innovate