ISAs, Stacks, and Endianness

CS 2130: Computer Systems and Organization 1

October 5, 2022

Announcements

- Homework 4 due Monday, 11pm on Gradescope

Instruction Set Architecture

Instruction Set Architecture (ISA) is an abstract model of a computer defining how the CPU is controlled by software

- Provides an abstraction layer between:
  - Everything computer is really doing (hardware)
  - What programmer using the computer needs to know (software)
- Hardware and Software engineers have freedom of design, if conforming to ISA
- Can change the machine without breaking any programs

CSO: covering many of the times we'll need to think across this barrier

Instruction Set Architecture

Backwards compatibility

- Include flexibility to add additional instructions later
- Original instructions will still work
- Same program can be run on PC from 10+ years ago and new PC today

Most manufacturers choose an ISA and stick with it

- Notable Exception: Apple

Our Instruction Set Architecture

What about our ISA?

- Enough instructions to compute what we need
- As is, lot of things that are painful to do
  - This was on purpose! So we can see limitations of ISAs early

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Our Instruction Set Architecture

icode	b	meaning
0		`rA = rB`
1		`rA += rB`
2		`rA &= rB`
3		`rA` = read from memory at address `rB`
4		write `rA` to memory at address `rB`
5	0	`rA = ~rA`
	1	`rA = -rA`
	2	`rA = !rA`
	3	`rA = pc`
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

What about real ISAs?

Our Instruction Set Architecture

What about our ISA?

- Enough instructions to compute what we need
- As is, lot of things that are painful to do
  - This was on purpose! So we can see limitations of ISAs early
- Add any number of new instructions using the reserved bit (7)
- Missing something important: *Help to put variables in memory*

Storing Variables in Memory

So far… we/compiler chose location for variable

Consider the following example:

```
f(x):
    a = x
    if (x <= 0) return 0
    else return f(x-1) + a
```

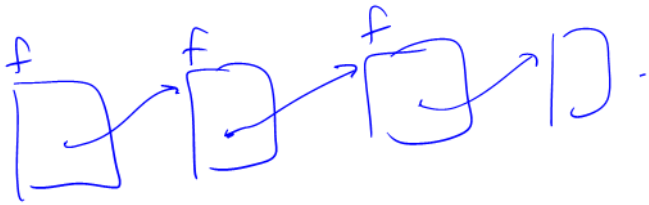
Recursion

- The formal study of a function that calls itself

Storing Variables in Memory

```
f(x):
    a = x
    if (x <= 0) return 0
    else return f(x-1) + a
```

Where do we store a?



The Stack

Stack - a last-in-first-out (LIFO) data structure

- *The* solution for solving this problem

`rsp` - Special register - the *stack pointer*

- Points to a special location in memory
- Two operations most ISAs support:
  - `push` - put a new value on the stack
  - `pop` - return the top value off the stack

The Stack: Push and Pop

`push r0`

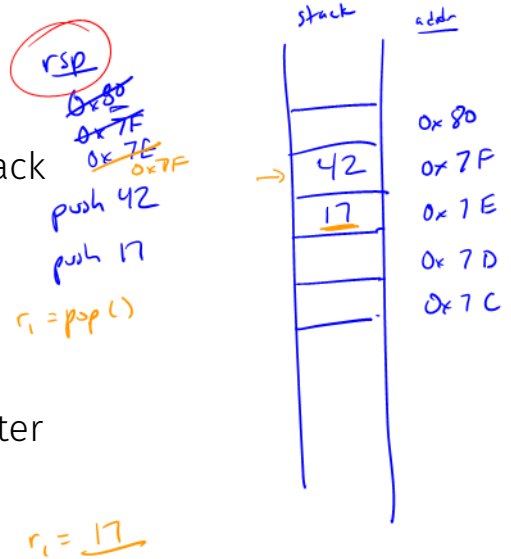
- Put a value onto the “top” of the stack

```
rsp -= 1
M[rsp] = r0
```

`pop r2`

- Read value from “top”, save to register

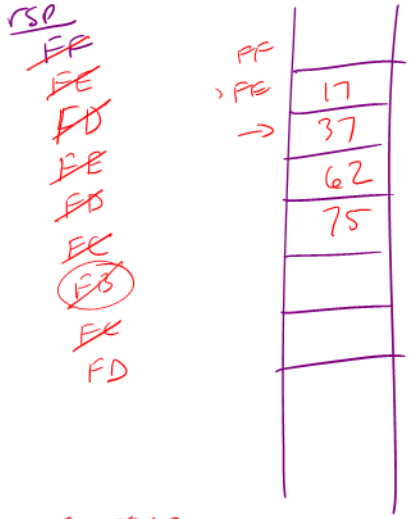
```
r2 = M[rsp]
rsp += 1
```



The Stack: Push and Pop

push 17
push 12
r_1 = pop()

push 37
push 62
push 75
r_1 = pop()
r_1 = pop()



r_1 = FC 75 62

The Stack: Push and Pop

Patents and Copyright

Can we patent our ISA? Should we?

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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/

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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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