Endianness, Assembly

CS 2130: Computer Systems and Organization 1

March 1, 2023

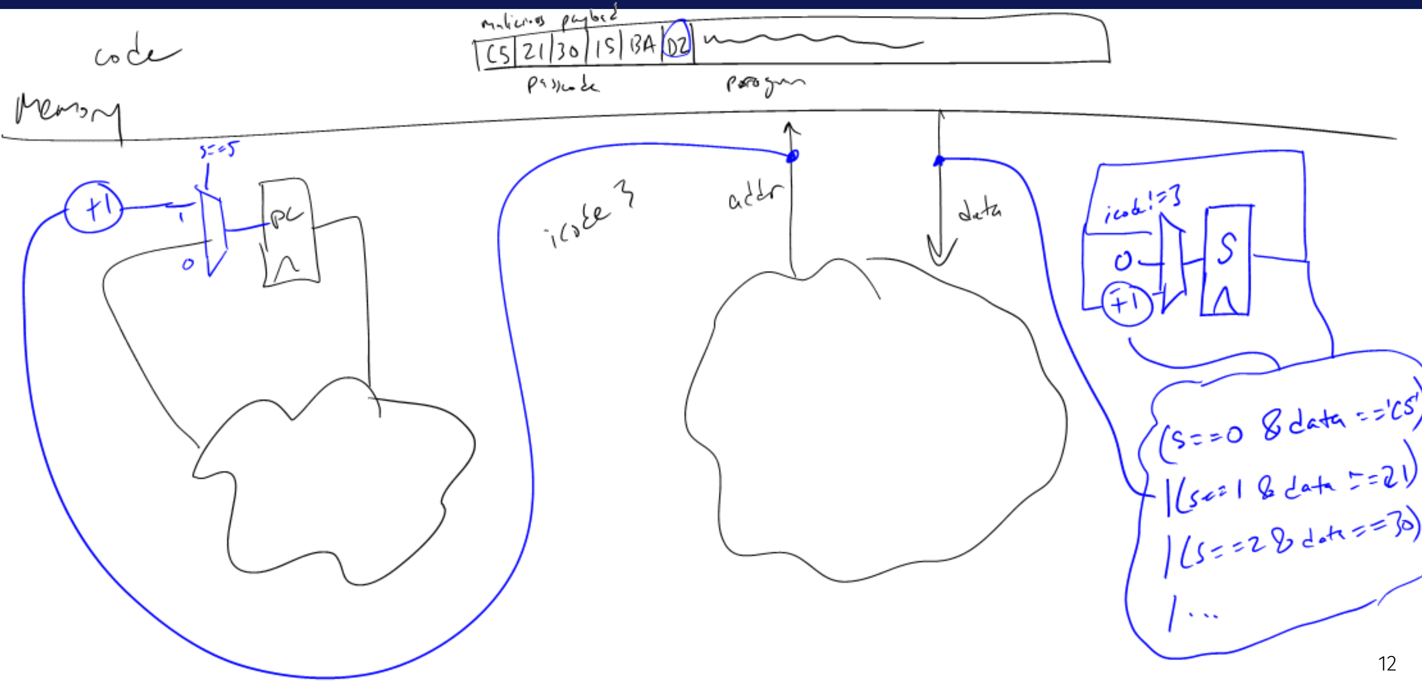
Announcements

- Homework 4 due **Friday** at 11pm on Gradescope
- Exam 1 scores released

Statistics

Mean	75.2
Median	78.0
Std. Dev.	18.66

Our Hardware Backdoor



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- Modern chips have **billions** of transistors
- We’re talking adding a few hundred transistors
- *Maybe with a microscope? But you’d need to know where to look!*

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Our Hardware Backdoor

Have you heard about something like this before?

- Sounds like something from the movies
- People claim this might be happening
- To the best of my knowledge, no one has ever *admitted* to falling in this trap

Ethics, Business, Tech

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Can we make a system where one bad actor can't break it?

- Code reviews, double checks, verification systems, automated verification systems, ...

Why does this work?

Why?

Why does this work?

- **It's all bytes!**
- Everything we store in computers are bytes
- We store code and data in the same place: memory

It’s all bytes

Memory, Code, Data… It’s all bytes!

- **Enumerate** - pick the meaning for each possible byte
- **Adjacency** - store bigger values together (sequentially)
- **Pointers** - a value treated as address of thing we are interested in

Enumerate

Enumerate - pick the meaning for each possible byte

What is 8-bit `0x54`?	
Unsigned integer	eighty-four
Signed integer	positive eighty-four
Floating point w/ 4-bit exponent	twelve
ASCII	capital letter T: **T**
Bitvector sets	The set $\{2, 3, 5\}$
Our example ISA	Flip all bits of value in r1

Adjacency

Adjacency - store bigger values together (sequentially)

- An array: build bigger values out of many copies of the same type of small values
  - Store them next to each other in memory
  - Arithmetic to find any given value based on index
- Records, structures, classes
  - Classes have fields! Store them adjacently
  - Know how to access (add offsets from base address)
  - If you tell me where object is, I can find fields

a[i]

addr + (i x size of item)

b, x

addr + offsetofx

Pointers

Pointers - a value treated as address of thing we are interested in

- A value that really points to another value
- Easy to describe, hard to use properly
- *We'll be talking about these a lot in this class!*
- Give us strange new powers (represent more complicated things), e.g.,
  - Variable-sized lists
  - Values that we don't know their type without looking
  - Dictionaries, maps

Programs Use These!

How do our programs use these?

- Enumerated icodes, numbers
- Ajacently stored instructions (PC+1)
- Pointers of where to jump/goto (addresses in memory)

Moving On

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

So far, we've been dealing with an 8-bit machine!

64-bit Machines

64-bit machine: The **registers** are 64-bits

- i.e., r0, but also PC

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Aside: Powers of Two

Powers of Two

Value	base-10	Short form	Pronounced
2^{10}	1024	Ki	Kilo
2^{20}	1,048,576	Mi	Mega
2^{30}	1,073,741,824	Gi	Giga
2^{40}	1,099,511,627,776	Ti	Tera
2^{50}	1,125,899,906,842,624	Pi	Peta
2^{60}	1,152,921,504,606,846,976	Ei	Exa

Example: 2^{27} bytes

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Example: 2^{27} bytes $= 2^7 \times 2^{20}$ bytes $= 2^7$ MiB $= 128$ MiB

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- 16 EiB (2^{64} addresses = $2^4 \times 2^{60}$)
- But I only have 8 GiB of RAM

A Challenge

There is a disconnect:

- Registers: 64-bits values
- Memory: 8-bit values (i.e., **1 byte** values)
  - Each address addresses an 8-bit value in memory
  - Each address points to a 1-byte slot in memory

A Challenge

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- Registers: 64-bits values
- Memory: 8-bit values (i.e., **1 byte** values)
  - Each address addresses an 8-bit value in memory
  - Each address points to a 1-byte slot in memory
- How do we store a 64-bit value in an 8-bit spot?