

Discussion 03

Floating Point; RISC-V Intro

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Announcements

Agenda

- Floating Point
- RISC-V Intro

Floating Point

Floating Point Conversion

Floating Points

1	8	23
Sign	Exponent	Significand/Mantissa

For normalized floats,

$$Value = (-1)^{Sign} * 2^{Exp+Bias} * 1.mantissa_2$$

For denormalized floats,

$$Value = (-1)^{Sign} * 2^{Exp+Bias+1} * 0.mantissa_2$$

$$Bias = -(2^{\# \text{ of exponent bits}} - 1)$$

Decimal -> Floating Point

$$Value = (-1)^{Sign} * 2^{Exp+Bias} * 1.mantissa_2$$

10.75

- Convert to Binary w.r.t the floating point
 - 1010.11
- Shift floating point to match formula format
 - 1.01011 * 2³
- Read Output
 - Mantissa = 01100...0
 - Exp = 3 - Bias

Step Size

- Given a certain exponent, step size is the change in decimal value when we add 1 to the mantissa of binary FP

$$2^{exp+bias} * 1.mantissa \Rightarrow 1M...M.MMMM$$

- Step Size is difference between `1MM...M.MMM0` and `1MM...M.MMM1`
- 2^{-4} in this example

RISC-V

Assembly Basics

Assembly is...

- The direct output of compiled code
- Is not the final form of code
- Is still human-readable
- A set of instructions that can be directly understood by the system, after maybe some minor adjustments
- Built up of a single operation at a time
- Even more dumb than regular computer programs
- Read line by line when executed, except when told not to

Storage: Registers

- On-chip memory
- RV32 has 32 of them numbered x0-x31 (why not x32?)
- They are all functionally the same but conventionally different
- They're all 32 bits wide
- Anything can be stored in them (no types)
- NOT A VARIABLE

#	Name	Description	#	Name	Desc
x0	zero	Constant 0	x16	a6	Args
x1	ra	Return Address	x17	a7	
x2	sp	Stack Pointer	x18	s2	Saved Registers
x3	gp	Global Pointer	x19	s3	
x4	tp	Thread Pointer	x20	s4	
x5	t0	Temporary Registers	x21	s5	
x6	t1		x22	s6	
x7	t2		x23	s7	
x8	s0	Saved Registers	x24	s8	
x9	s1		x25	s9	
x10	a0	Function Arguments or Return Values	x26	s10	
x11	a1		x27	s11	
x12	a2	Function Arguments	x28	t3	Temporaries
x13	a3		x29	t4	
x14	a4		x30	t5	
x15	a5		x31	t6	
Caller saved registers					
Callee saved registers (except x0, gp, tp)					

Register Specifics

There are 4 general categories (and some special!):

1. Argument registers: `a0` - `a7`
2. Return value registers: `a0` , `a1`
3. Saved registers: `s0` - `s11`
4. Temporary registers: `t0` - `t6`

Special registers

- Return address: `ra` NOT RETURN VALUE!!!

Zero: `x0`

Stack pointer: `sp`

Other pointers: `tp` , `gp`

RISC-V Greensheet!

Loads

`l<u>x</u> rd imm(rs1)`

- Loads `n` bits worth of data from memory address: `rs1 + imm` where `rs1` `<u>should</u>` already be a valid address.
- `n` will depend on the instruction: `sb` = 8 bits, `sh` = 16 bits, `sw` = 32 bits, `sd` (not used usually) = 64 bits
- If we have too few bits...
 - Sign-extend
- If we have too many bits...
 - Take the 32-most LSB bits!

Stores

$s_{<u>x</u>} rd\ imm(rs1)$

- Saves n bits worth of data to the memory address: $rs2 + imm$
- Truncates to n LSB bits to be stored

Jump Instructions, `jal`, `jalr`, `j`, `jr`

	Saves return address	Jump and no return
PC-relative address	<code>jal ra, label</code>	<code>j label</code>
Address in a register	<code>jalr ra, rs1, imm</code>	<code>jr rs1</code>

`j` and `jr` are shorthand for common combinations of certain instructions and register usages.

```
j label # jal x0, label
jr rs1 # jalr x0, 0(rs1)
```