

CSC 411

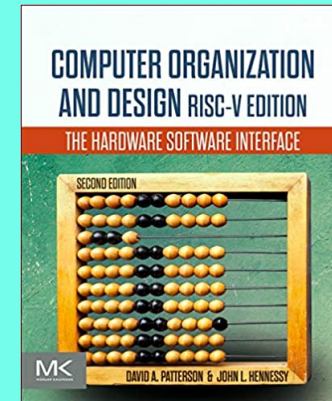
Computer Organization (Spring 2024)
Lecture 10: RISC-V load/store

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Disclaimer

Some figures and slides are adapted from:

Computer Organization and Design (Patterson and Hennessy)
The Hardware/Software Interface



So far ...

- Addition / subtraction

```
add rd, rs1, rs2  
sub rd, rs1, rs2
```

- Add immediate

```
addi rd, rs1, imm
```

Data transfer instructions

- RV32I is a load-store architecture

- only **load** and **store** instructions access memory
- arithmetic instructions only operate on CPU registers

- Memory is **byte-addressed**

- each address identifies an 8-bit byte
- RISC-V is **Little Endian**
- RISC-V and x86 do not require words to be **aligned** in memory (alignment strongly encouraged)
 - alignment restriction forces **words** to start at addresses that are multiples of the word size

Loading and storing data

- Values can be loaded from memory



- Values can be stored in memory



Loading words

- The **lw** instruction loads a 32-bit value from memory into rd

destination register base register
lw rd, **imm**(rs1)
 offset

destination register gets memory word from address (base + offset)

Storing words

- The **sw** instruction stores a 32-bit value from rs2 to memory

source register base register
sw rs2, **imm**(rs1)
 offset

memory at address (base + offset) gets the value in source register

Practice

- C code

- assume all are int variables

```
g = h + A[8];
```

- RISC-V code

- index 8 requires offset of 32 (4 bytes)
- assume g in x1, h in x2, and base address of A in x3

```
lw   x1, 32(x3)  
add x1, x2
```

Practice

▸ C code

- assume all are `int` variables

```
A[7] = h + A[5];
```

▸ RISC-V code

- assume `h` in `x1` and base address of `A` in `x2`
- can use an additional register `x3`

Loading and storing bytes

▸ Instructions for transferring individual bytes from/to memory

▸ Use same format as `lw` and `sw`

- load byte: **lb**
 - loads a 8-bit value from memory, then **sign-extends** to 32-bits before storing in `rd`
- load unsigned byte: **lbu**
 - loads a 8-bit value from memory but then **zero extends** to 32-bits before storing in `rd`
- store byte: **sb**
 - stores 8-bit value from the **low bits** of register `rs2` to memory

Practice

▸ What are the resulting values in `x3` and `x4` respectively?

- express the values using 32-bits (in hexadecimal notation)

```
addi x1, x0, 0x80AB
sw   x1, 0(x2)
lb   x3, 1(x2)
lbu  x4, 0(x2)
```

Practice

▸ Translate the following C code into RISC-V

- can use an additional register `x3`

```
// assume x, y are integer pointers
// stored in x1 and x2 respectively
*x = *y;
```

Registers vs memory

- Operating on memory data requires **loads** and **stores**
 - consider memory latency
 - memory is byte-addressable but **lw** and **sw** can transfer entire words
- **Registers** are a fast read/write memory right on the CPU that can hold values
- Compiler must use registers for variables as much as possible
 - only spill to memory for less frequently used variables
 - **register optimization** is important!