EI338 Computer System Engineering Homework 5

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Exercise 1 How many kinds of instructions? What is the role of each one?

Solution. There are three kinds of instructions.

1. **Data movement instructions** They move data from a memory location or register to another memory location or register without changing its form.

2. **Arithmetic and logic (ALU) instructions** They change the form of one or more operands to produce a result stored in another location. Typical instructions involve `Add, Sub, Shift,` etc.

3. **Branch instructions (control flow instructions)** They alter the normal flow of control from executing the next instruction in sequence.

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Exercise 2 How many kinds of ISAs? What are the advantages and disadvantages of each ISA?

Solution.

1. Stack Architecture

   - Advantages
     - The machine code is dense since the operands will be stored in a fixed location and need not be specified
     - Low hardware requirements
     - Its compiler is easy to implement
   - Disadvantages
     - Stack becomes the bottleneck and there is little potential for parallelism or pipelining
     - Since data is not always at the top of stack when needed, so additional instructions like `TOP` and `SWAP` are needed.
     - It is difficult to write an optimizing compiler for stack architectures

2. Accumulator Architecture

   - Advantages
     - Its hardware requirements are very Low
     - It is easy to design and understand
   - Disadvantages
     - There is heavy memory traffic
     - The accumulator will become the bottleneck and there is little potential for parallelism and pipelining

3. Memory Memory Architecture

- Advantages
  - Its instruction codes are compact
  - Its compiler is easy to implement
- Disadvantages
  - There is very heavy memory traffic
  - The clock cycle of every instruction will vary.
  - With two operands, more data movements are required

4. Register-Memory Architectures

- Advantages
  - Some data can be accessed without loading first
  - The instruction format is easy to encode
  - Good code density
- Disadvantages
  - Since operands can either be registers or memory addresses, they are not equivalent.
  - The number of clocks per instruction may vary
  - Number of registers will be limited

5. Load Store Architectures

- Advantages
  - The instruction encoding is simple and fixed in length.
  - Instructions will take similar number of cycles.
  - They are relatively easy to pipeline.
- Disadvantages
  - Higher instruction count.
  - Not all instructions need three operands, the instruction format may be redundant.
  - Dependent on good compiler

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Exercise 3 MIPS architecture provides 32 GPRS (general purpose register). What is the function of each register?

Solution.

Register Number	Conventional Name	Usage
$0	$zero	Hard-wired to 0
$1	$at	Reserved for pseudo-instructions
$2 - $3	$v0, $v1	Return values from functions
$4 - $7	$a0 - $a3	Arguments to functions - not preserved by subprograms
$8 - $15	$t0 - $t7	Temporary data, not preserved by subprograms
$16 - $23	$s0 - $s7	Saved registers, preserved by subprograms
$24 - $25	$t8 - $t9	More temporary registers, not preserved by subprograms
$26 - $27	$k0 - $k1	Reserved for kernel. Do not use.
$28	$gp	Global Area Pointer (base of global data segment)
$29	$sp	Stack Pointer
$30	$fp	Frame Pointer
$31	$ra	Return Address

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