

RICHARD ROBINSON

ASSEMBLY LANGUAGE

Contents

<i>Introduction</i>	5
---------------------	---

Introduction

Performance Metrics

There are several metrics of performance of programs by processors. These include

- *Execution time*, the total time required for the computer to complete a task (also called response time).
- *Bandwidth*, the number of tasks completed per unit time (also called throughput).
- *Performance*, the inverse of execution time.
- *Clock cycle*, the time for one (processor) clock period, which runs at a constant rate.

Consequently, the CPU time is defined as

$$t_{\text{cpu}} = n_{\text{cycles}} / r_{\text{clock}} \quad \text{for} \quad n_{\text{cycles}} = I \times \text{CPI} \quad (1)$$

The MIPS unit is another performance metric, given by

$$\text{MIPS} = I / t_{\text{exec.}} \cdot 10^6 = r_{\text{clock}} / \text{CPI} \cdot 10^6 \quad (2)$$

CPI: the average number of clock cycles per instruction for a program.

MIPS: A measurement of program execution speed based on the number of millions of instructions.

RISC-V Syntax

RISC-V is an assembly language with a basic syntax of

```
add x1, x2, x3      // x1 = x2 + x3
```

The operands x0-x31 are the 32 registers with x0 always equaling 0. Data must be in registers for arithmetic. Additionally, there are 2^{61} memory words Memory[8i] which may be accessed only by data transfer instructions.

In RISC-V, a doubleword is a group of 64 bits. There are never any variables in RISC-V; all variables are converted into respective registers. For example, if g and h are x20, x21 and the base address is x22 of array A, then the C code

Word: Half of a doubleword; a group of 32 bits.

Address: The index for a data element in a memory array.

$$A[z] = h + A[y]$$

in RISC-V is translated to

```
ld    x9, 8y(x22)    // temp reg x9 gets A[y]
add   x9, x21, x9     // temp reg x9 gets h + A[y]
sd    x9, 8z(x22)     // stores x9 into A[z]
```

The reg added to form the address (x22) is the *base reg* and the DTI constant (64) is the *offset*. To get the proper byte address, the offset to be added to the base reg is $8c$ where c is the initial constant.

Byte: A group of 8 bits; there are 8 bytes in a doubleword.

This implies that the byte address of an element is a multiple of 8; that is, element i has byte address $8i$ where the first element is i_0 .

Binary & Hexadecimal

Binary to decimal base is calculated via

$$\sum x_i 2^i \quad (3)$$

where x_i is the i th digit starting at $i = 0$ and increasing leftwards. In RISC-V, the least or most sig. bit is the rightmost or leftmost bit, respectively.

Two's complement representation for signed binary numbers assigns leading 0s as positive and leading 1s as negative. The complements are related by

$$\bar{x} + 1 = -x \quad (4)$$

In Hexadecimal, all groups of 4 binary digits may be represented by a single hexadecimal digit, ranging from 0 – 9, $a - f$.