

COAL Lab # 03

Introduction to Assembly Language & Venus Simulator

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Literature Review:

Assembly Language:

Assembly language is the human-readable representation of the computer's native language. Each assembly language instruction specifies both the operation to perform and the operands on which to operate. We introduce simple arithmetic instructions and show how these operations are written in assembly language. We then define the RISC-V instruction operands: registers, memory, and constants.

Venus simulator:

Venus is an emulator for RISC-V computers. It allows users to run programs written in RISC-V assembly language without having access to a computer running a RISC-V chip.

Registers:

Instructions need to access operands quickly so that they can run fast, but operands stored in memory take a long time to retrieve. Therefore, most architectures specify a small number of registers that hold commonly used operands. The RISC-V architecture has 32 registers, called the register set, stored in a small multi ported memory called a register file. The fewer the registers, the faster they can be accessed.

Machine Language:

Assembly language is convenient for humans to read. However, digital circuits understand only 1's and 0's. Therefore, a program written in assembly language is translated from mnemonics to a representation using only 1's and 0's, called machine language. RISC-V makes the compromise of defining four main instruction formats: R-type, I-type, S/B-type, and U/J-type.

Lab Exercise 01

Task:

Translate the Given High Level Code to Assembly Language

High - Level Code	RISC-V Assembly Code
a = b - c;	sub x18,x19,x29
f = (g + h) - (i + j);	add x5,x18,x19 add x6,x20,x21 sub x22,x5,x6

Lab Exercise 02

Task:

Convert the following RISC-V Assembly code into Machine Code

Assembly:

add x9, x5, x6

andi x10, x8, 0x6

or x5, x6, x7

slli x10, x6, 0x8

Machine Code:

0000 0000 0110 0010 1000 0100 1011 0011

0000 0000 0110 0100 0111 0101 0001 0011

0000 0000 0111 0011 0110 0010 1011 0011

0000 0000 1000 0011 0001 0101 0001 0011

Hexa Code:

0x006284B3

0x00647513

0x007362B3

0x00831513

In Lab Tasks

Task:

Convert the Given High Level Code on RISC-V Assembly and run it on Venus Simulator. Also write down its Machine Code

a) $a = a + 4;$
 $b = a - 12;$

Assembly:

addi x18, x18, 0x4

addi x19, x18, -12

Machine Code:

0000 0000 0100 1001 0000 1001 0001 0011

1111 1111 0100 1001 0000 1001 1001 0011

Hexa Code:

0x00490913

0xFF490993

Venus Output:

The screenshot shows the Venus ARM simulator interface. At the top, there are tabs for 'Venus', 'Editor', 'Simulator', and 'Chocopy'. Below the tabs, there are buttons for 'Run', 'Step', 'Prev', 'Reset', 'Dump', 'Trace', and 'Re-assemble from Editor'. The main area displays a table of assembly code:

PC	Machine Code	Basic Code	Original Code
0x0	0x00490913	addi x18, x18, 4	addi x18, x18, 0x4
0x4	0xFF490993	addi x19, x18, -12	addi x19, x18, -12

On the right side, there is a list of registers (s7, s2, s3, s4, s5, s6, s7, s8) with their corresponding values. The values are: s7 (x17) = 0, s2 (x18) = 4, s3 (x19) = -8, s4 (x20) = 0, s5 (x21) = 0, s6 (x22) = 0, s7 (x23) = 0, and s8 (x24) = 0. At the bottom, there is a 'console output' area with buttons for 'Copy!', 'Download!', and 'Clear!'. A 'Display' dropdown menu is also visible, set to 'Decimal'.

b) if ($g < h$)

$g = g + 1;$

else

$h = h - 1;$

Assembly:

blt x18,x19,Label

addi x19, x19, -1

Label:

addi x18,x18,0x1

Machine Code:

0000 0001 0011 1001 0100 0100 0110 0011

1111 1111 1111 1001 1000 1001 1001 0011

0000 0000 0001 1001 0000 1001 0001 0011

Hexa Code:

0x01394463

0xFFFF98993

0x00190913

Venus Output:

The screenshot shows the Venus MIPS simulator interface. At the top, there are tabs for 'Venus', 'Editor', 'Simulator', and 'Chocopy'. Below the tabs are buttons for 'Run', 'Step', 'Prev', 'Reset', 'Dump', 'Trace', and 'Re-assemble from Editor'. The main area displays a table with four columns: 'PC', 'Machine Code', 'Basic Code', and 'Original Code'. The table contains three rows of assembly instructions. To the right of the table, there is a list of registers (a6, a7, s2, s3, s4, s5, s6) with their corresponding values. The 's3' register is highlighted with a blue border and contains the value '-1'. At the bottom, there is a 'console output' area and buttons for 'Copy!', 'Download!', and 'Clear!'. The 'Display' dropdown menu is set to 'Decimal'.

PC	Machine Code	Basic Code	Original Code
0x0	0x01394463	blt x18 x19 8	blt x18,x19,Label
0x4	0xFFFF98993	addi x19 x19 -1	addi x19, x19, -1
0x8	0x00190913	addi x18 x18 1	addi x18,x18,0x1

Registers:

- a6 (x15): 0
- a7 (x16): 0
- s2 (x17): 1
- s3 (x18): -1
- s4 (x19): 0
- s5 (x20): 0
- s6 (x21): 0
- (x22): 0

Display: Decimal

Post Lab Tasks

Task:

Write down a simple C program to add, multiply and divide two integer numbers. Convert the C code into assembly and machine code and stimulate it on Venus.

C program:

```
int a = 5+2;  
int m = 2*2;  
int d = 6/2;
```

Assembly:

```
addi x18,x18,0x5  
addi x18,x18,0x2  
  
addi x19,x19,0x2  
mul x19,x19,x19  
  
addi x25,x25,0x6  
addi x26,x26,0x2  
div x20,x25,x26
```

Machine Code:

```
0000 0000 0101 1001 0000 1001 0001 0011  
0000 0000 0010 1001 0000 1001 0001 0011
```

0000 0000 0010 1001 1000 1001 1001 0011

0000 0011 0011 1001 1000 1001 1011 0011

0000 0000 0110 1100 1000 1100 1001 0011

0000 0000 0010 1101 0000 1101 0001 0011

0000 0011 1010 1100 1100 1010 0011 0011

Hexa Code:

0x00590913

0x00290913

0x00298993

0x033989B3

0x006C8C93

0x002D0D13

0x03ACCA33

Venus Output:

The screenshot shows the Venus simulator interface with the 'Simulator' tab selected. The main window displays a table of assembly instructions being executed. Below the table are buttons for 'Run', 'Step', 'Prev', 'Reset', 'Dump', 'Trace', and 'Re-assemble from Editor'. To the right, a vertical stack of registers is visible, with values for s2, s3, s4, s5, and s6. At the bottom, there is a 'console output' area and a 'Display' dropdown set to 'Decimal'.

PC	Machine Code	Basic Code	Original Code
0x0	0x00590913	addi x18 x18 5	addi x18,x18,0x5
0x4	0x00290913	addi x18 x18 2	addi x18,x18,0x2
0x8	0x00298993	addi x19 x19 2	addi x19,x19,0x2
0xc	0x033989B3	mul x19 x19 x19	mul x19,x19,x19
0x10	0x006C8C93	addi x25 x25 6	addi x25,x25,0x6
0x14	0x002D0D13	addi x26 x26 2	addi x26,x26,0x2
0x18	0x03ACCA33	div x20 x25 x26	div x20,x25,x26

Registers (x15) to (x22):

- (x15): 0
- (x16): 0
- (x17): 0
- (x18): 7
- (x19): 4
- (x20): 3
- (x21): 0
- (x22): 0

Display: Decimal

A close-up view of the registers in the Venus simulator. The registers s2 (x18), s3 (x19), and s4 (x20) are visible. The values are 7, 4, and 3 respectively. The register s3 (x19) is highlighted with a blue border.

Registers (x18) to (x22):

- (x18): 7
- (x19): 4
- (x20): 3

Task:

Write down a simple C program to find out the prime numbers between 1-10 and give the final count of prime numbers. Convert the C code into assembly and machine code and stimulate it on Venus.

C code:

```
#include <stdio.h>

int main() {

    int c = 0;
    int flag;
    for(int i=2; i<11; i++){
        flag = 1;
        for(int j=2; j<(i/2); j++){
            if((i%j) == 0){
                flag = 0;
            }
        }
        if(flag){
            c++;
        }
    }

    printf("%d",c);

    return 0;
}
```

Assembly:

```
j main

main:
    addi x18,x18,0x2 # int i=2;
    addi x25,x0,0x1  # int 1 = 1;
    addi x22,x22,50  # int 11 = 11
    addi x21,x21,0x1 # int flag = 1
    Counter:
    beq x21,x25,CounterAdd # c++
    OuterLoop:
    addi x18,x18,0x1 # i++
    addi x21,x0,0x1 # flag = 1;
    addi x19,x0,0x2 # j = 2
    div x31,x18,x19
    blt x18,x22,Outer # for(int i=2; i<11);
```

```

    j End # if outer loop condition false the end

# if Outer loop condition true

InnerLoop:
    addi x19,x19,0x1
Outer:
    blt x19,x18,Condition # for(int j=2; j<i);
    j Counter

Condition:
    rem x24,x18,x19
    beq x24,x0,PrimeFalse
    j InnerLoop

PrimeFalse:
    addi x21,x0,0x0
    j OuterLoop

CounterAdd:
    addi x20,x20,0x1
    j OuterLoop

End:

```

Machine Code:

```

0000 0000 0010 1001 0000 1001 0001 0011
0000 0000 0001 0000 0000 1100 1001 0011
0000 0000 1011 1011 0000 1011 0001 0011
0000 0000 0001 1010 1000 1010 1001 0011
0000 0011 1001 1010 1000 1110 0110 0011
0000 0000 0001 1001 0000 1001 0001 0011
0000 0000 0001 0000 0000 1010 1001 0011
0000 0000 0010 0000 0000 1001 1001 0011
0000 0011 0011 1001 0100 1111 1011 0011
0000 0001 0110 1001 0100 0110 0110 0011

```

0000 0000 0001 1001 1000 1001 1001 0011
0000 0001 0010 1001 1100 0100 0110 0011
0000 0011 0011 1001 0110 1100 0011 0011
0000 0000 0000 1100 0000 0100 0110 0011
0000 0000 0000 0000 0000 1010 1001 0011
0000 0000 0001 1010 0000 1010 0001 0011

Hexa Code:

0x00290913

0x00100C93

0x00BB0B13

0x001A8A93

0x039A8E63

0x00190913

0x00100A93

0x00200993

0x03394FB3

0x01694663

0x00198993

0x0129C463

0x03396C33

0x000C0463

0x00000A93

0x001A0A13

Venus Output:

Run	Step	Prev	Reset	Dump	Trace	Re-assemble from Editor
PC	Machine Code	Basic Code	Original Code			
0x0	0x0040006F	jal x0 4	j main			
0x4	0x00290913	addi x18 x18 2	addi x18,x18,0x2 # int i=2;			
0x8	0x00100C93	addi x25 x0 1	addi x25,x0,0x1 # int 1 = 1;			
0xc	0x008B0B13	addi x22 x22 11	addi x22,x22,0xB # int 11 = 11			
0x10	0x001A8A93	addi x21 x21 1	addi x21,x21,0x1 # int flag = 1			
0x14	0x039A8E63	beq x21 x25 60	beq x21,x25,CounterAdd # c++			
0x18	0x00190913	addi x18 x18 1	addi x18,x18,0x1 # i++			
0x1c	0x00100A93	addi x21 x0 1	addi x21,x0,0x1 # flag = 1;			
0x20	0x00200993	addi x19 x0 2	addi x19,x0,0x2 # j = 2			
0x24	0x03394FB3	div x31 x18 x19	div x31,x18,x19			
0x28	0x01694663	blt x18 x22 12	blt x18,x22,Outer # for(int i=2; i<11);			

Run	Step	Prev	Reset	Dump	Trace	Re-assemble from Editor
0x20	0x01094003	div x10 x22 12	div x10,x22,Outer # for(int i=2; i<11);			
0x2c	0x02C0006F	jal x0 44	j End # if outer loop condition false the end			
0x30	0x00198993	addi x19 x19 1	addi x19,x19,0x1			
0x34	0x0129C463	blt x19 x18 8	blt x19,x18,Condition # for(int j=2; j<i);			
0x38	0xFDDFF06F	jal x0 -36	j Counter			
0x3c	0x03396C33	rem x24 x18 x19	rem x24,x18,x19			
0x40	0x000C0463	beq x24 x0 8	beq x24,x0,PrimeFalse			
0x44	0xFEDFF06F	jal x0 -20	j InnerLoop			
0x48	0x00000A93	addi x21 x0 0	addi x21,x0,0x0			
0x4c	0xFCDF06F	jal x0 -52	j OuterLoop			
0x50	0x001A0A13	addi x20 x20 1	addi x20,x20,0x1			
0x54	0xFC5FF06F	jal x0 -60	j OuterLoop			

final output register

s4 (x20)

4

