Assignment # 2 : Instruction-Level Parallelism Report

- Deliverables :

sim_seq.cpp	Simulator executing the program in a sequential mode .i.e. non-pipelined. It displays step by step execution of the assembly program displaying the cycles consumed by each instruction.
sim_p.cpp	Simulator executing the program in a pipeline mode i.e. 5 stage pipeline. **Forwarding technique is not used.**
sim_t.cpp	Simulator executing the program using tomasulo dynamic scheduling technique.
arch_params_file	Parameters file containing the simulator architecture parameters.
init_mem_file	Binary file to initialize the memory. The two matrices are stored from the memory address **100** and **800** respectively. The results are stored starting from memory address **1608.** The file size is 1 MB.
matrix.asm	The matrix multiplication program using the given instruction set. This program multiplies **3 X 3** matrices. Couple of parameter needs to be changed inside this file in order to do matrix multiplication of different order. This program supports multiplication of only square matrices.
Createmem.cpp	Utility program used to create as well as read the memory dump.
Makefile	Builds **sim_seq**, **sim_p**, **sim_t** and **createmem** executables.

- All the three programs give a detailed step by step information regarding execution of the assembly program. Finally, all of them display the total number of CPU cycles consumed, number of stalls encountered and CPI.
- All the three programs take 4 parameters and should be executed in the following format.
    - ./**sim_seq** arch_params_file ini_mem_file matrix.asm output_mem_file
    - ./**sim_p** arch_params_file ini_mem_file matrix.asm output_mem_file
    - ./**sim_t** arch_params_file ini_mem_file matrix.asm output_mem_file
- **createmem** program gives you a choice of creating a new memory file to initialize the program or read an existing memory file. The output dump can be read by using this utility.
- Please make sure the input assembly program does not contain tabs. Instead please use spaces.
- To get the detailed execution steps and path, the output of any program can be directed to a file and the file can be analyzed later using a text editor .i.e.

  ./sim_t arch_params_file ini_mem_file matrix.asm output_mem_file **> output.txt**
- **Statistics**:

  Below parameter values were used to get the statistics for matrix.asm (3X3).

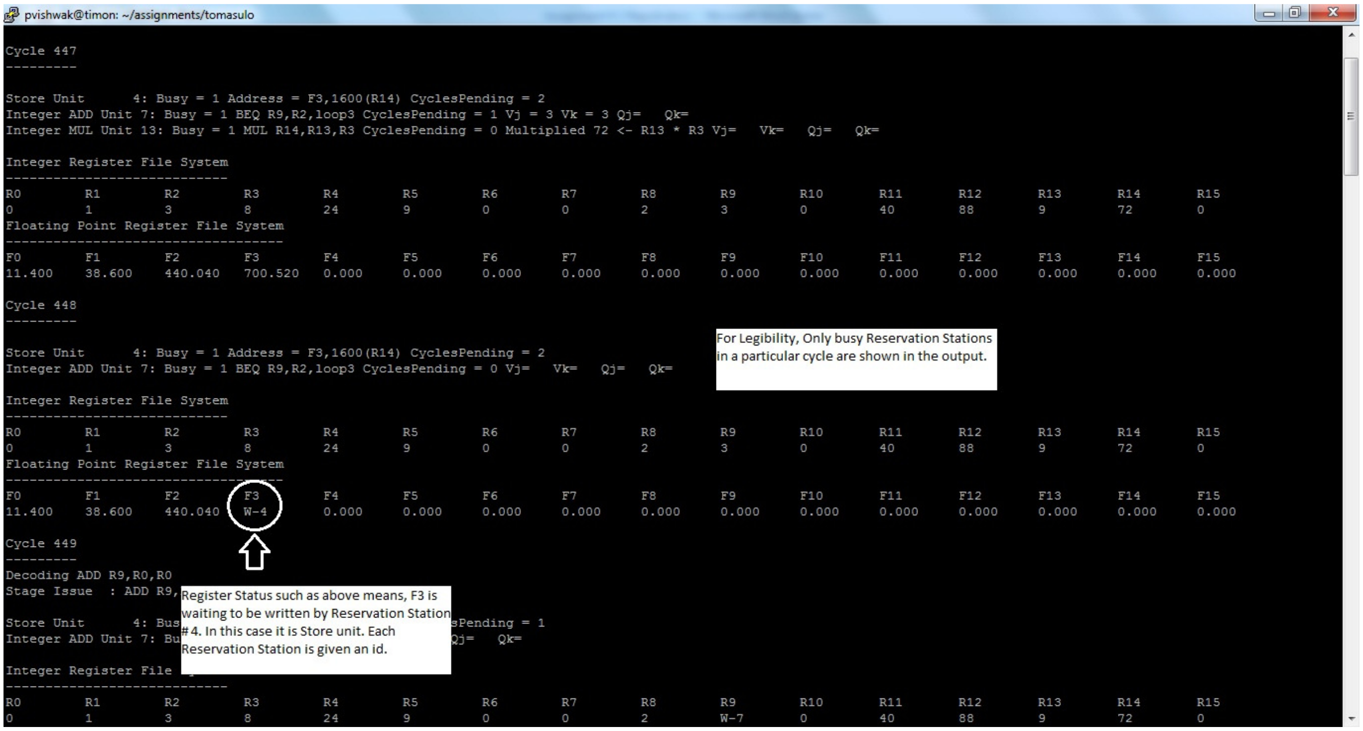
  NOOP 1, ADD 2, ADD.D 2, DIV 5, DIV.D 5, SUB 2, SUB.D 2, MUL 5, MUL.D 5, L 2
  LI 2, S 2, L.D 2, S.D 2, BEQ 2, BNEQ 1, BGTZ 1, BLTZ 1, MOVE 2, BEQ.D 2
  BNEQ.D 1, BGTZ.D 1, BLTZ.D 1, MOVE.D 2
  loads 3, stores 3, intadds 3, fpadds 3, intmuls 2, fpmuls 2, intdivs 2, fpdivs 2

	sim_seq	sim_p	sim_t
Total Cycles	811	986	472
Total Instructions Fetched	330	363	330
No. of stalls	-	652	61
CPI	2.46	2.72	1.43

Note 1: Total Instructions Fetched for sim_p is more because the simulator is considering branch untaken before the branch instruction is evaluated in the decode stage.

Note 2: sim_p doesn't use **forwarding**.

- ## Interpreting the Output for tomasulo



pvishwak@timon: ~/assignments/tomasulo

```
Cycle 447
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Store Unit      4: Busy = 1 Address = F3,1600(R14) CyclesPending = 2
Integer ADD Unit 7: Busy = 1 BEQ R9,R2,loop3 CyclesPending = 1 Vj = 3 Vk = 3 Qj=   Qk=
Integer MUL Unit 13: Busy = 1 MUL R14,R13,R3 CyclesPending = 0 Multiplied 72 <- R13 * R3 Vj=   Vk=   Qj=   Qk=

Integer Register File System
----------------------------
R0        R1        R2        R3        R4        R5        R6        R7        R8        R9        R10       R11       R12       R13       R14       R15
0         1         3         8         24        9         0         0         2         3         0         40        88        9         72        0
Floating Point Register File System
-----------------------------------
F0        F1        F2        F3        F4        F5        F6        F7        F8        F9        F10       F11       F12       F13       F14       F15
11.400    38.600    440.040   700.520   0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000

Cycle 448
---------

Store Unit      4: Busy = 1 Address = F3,1600(R14) CyclesPending = 2
Integer ADD Unit 7: Busy = 1 BEQ R9,R2,loop3 CyclesPending = 0 Vj=   Vk=   Qj=   Qk=

Integer Register File System
----------------------------
R0        R1        R2        R3        R4        R5        R6        R7        R8        R9        R10       R11       R12       R13       R14       R15
0         1         3         8         24        9         0         0         2         3         0         40        88        9         72        0
Floating Point Register File System
-----------------------------------
F0        F1        F2        F3        F4        F5        F6        F7        F8        F9        F10       F11       F12       F13       F14       F15
11.400    38.600    440.040   W-4       0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000

Cycle 449
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Decoding ADD R9,R0,R0
Stage Issue  : ADD R9,

Store Unit      4: Bus                                    sPending = 1
Integer ADD Unit 7: Bu                                    Qj=   Qk=

Integer Register File
----------------------------
R0        R1        R2        R3        R4        R5        R6        R7        R8        R9        R10       R11       R12       R13       R14       R15
0         1         3         8         24        9         0         0         2         W-7       0         40        88        9         72        0
```

For Legibility, Only busy Reservation Stations in a particular cycle are shown in the output.

Register Status such as above means, F3 is waiting to be written by Reservation Station # 4. In this case it is Store unit. Each Reservation Station is given an id.

Note 1: Register status such as shown above (encircled – W-4 under F3) means in this case, value of F3 would be written by Reservation Station # 4. Each Reservation Station is assigned a unique identifier.

Note 2: For legibility, reservation stations that are **busy** on a particular cycle are shown in the output and not all.