

./run181031.sh
TEST DATE: 181031

LIST OF INITIALIZATION PARAMETERS
-----[General]

Program Name = prog181031
Silent = no
Interactive = yes
Batch File = no

-----[Architecture]

Logical Registers = 8
Physical Registers = 8
Pipeline Structure = FDPXWC
Unified LSU = yes
In-Order Issue = no
In-Order Complete = no
Unified Dispatch/Issue = yes
Fetch Width = 4
Decode Width = 4
Issue Width = 4
Write-Back Width = 4
Commit Width = 4
Window Size = 8
ROB Size = 10
Integer ALU Units = 4
Integer ALU Latency = 0
Integer Mult. Units = 1
Integer Mult. Latency = 4
Integer Mult. Pipe = yes
Floating Point Units = 4
Floating Point Mult = 1
Load Units = 1
Load Latency = 2
Load Pipe = yes
Store Units = 1
Store Latency = 1
Store Pipe = yes
Branch Units = 1
Branch Latency = 0
Load Queue Size = 3
Store Queue Size = 3

-----[Program Defaults]

Log File Name = def.log

* Input program: 'prog181031'
000) 35 2 1 0 --> LW R2,0(R1)
001) 24 4 2 2 --> MUL R4,R2,R2
002) 43 4 1 0 --> SW R4,0(R1)
003) 8 1 1 4 --> ADDI R1,R1,4
004) 5 2 0 -5 --> BNE R2,R0,-5
* TOTAL_INSTRUCTIONS=5
* DEFAULT_NUMBER_OF_ITERATIONS=3
- STAGE = 4 entries.
FETCH STAGE = 4 entries.
DECODE STAGE = 4 entries.
DISPATCH STAGE = 8 entries.
ISSUE STAGE = 4 entries.
EXECUTE STAGE = 12 entries.
COMPLETE STAGE = 4 entries.
COMMIT STAGE = 4 entries.

Consider the following snippet of code running on 4-ways out-of-order superscalar processor.
Initially, R1=0x1000, R3=0x3000, R7=0x0003 and the other registers contain zero.

```
lab1: LW R2,0(R1)
      MUL R4,R2,R2
      SW R4,0(R1)
      ADDI R1,R1,4
      BNE R2,R0,lab1
```

- Working hypothesis:
- * the fetch, decode and commit stages are 4 instructions wide
 - * the instruction window has 8 slots
 - * we have 8 physical registers in the free pool
 - * the reorder buffer has 10 entries
 - * the integer multiplier has 4 stages
 - * the load/store queues have 3 slots each and a common effective-address calculation unit
 - * there are 4 ALUs for arithmetic and logic operations and for branching
 - * an ALU/BRANCH performs its operation in the same cycle when the operation is issued
 - * reads require 1 clock cycle (after the addressing phase)
 - * the register file has 4 input- and 4 output-ports
 - * there are 9 logical registers (including R0 which is hardwired to 0)
 - * the store operation leaves the issue stage as it is inserted in the store queue
 - * when the X stage finds a free slot in the LQ/SQ, also a slot in the I stage is reserved
 - * branches are predicted taken

In order to calculate the total cycles needed to execute 3 iterations of the above loop on such machine, complete the following chart until the end of the third iteration of the code fragment above, including the renamed stream the precise evolution of the free pool of the physical registers (the register map), the Instruction Window, the Reorder Buffer (ROB) and the Load Queue (LQ) and Store Queue (SQ).

PHYSICAL REGS: 1 2 3 4 5 6 7 8

qi: 1 1 1 1 1 1 1 1
vi: 00 00 00 00 00 00 00 00

REG. FILE: Ri: 1 2 3 4 5 6 7 8
Pi: - - - - - - - -
Qi: 0 0 0 0 0 0 0 0
Vi: 00001000 00000000 00003000 00000000 00000000 00000000 00000003 00000000

| STAGES: | F | D | P | I | X | W | C | RENAMED-STR | INSTRUCTION-WINDOW | REORDER-BUFFER | A | M | L | S | B | F | X |
|--------------|---|---|---|---|----|---|---|-------------|--------------------|----------------|---|---|---|---|---|---|---|
| TOTAL SLOTS: | 4 | 4 | 8 | 4 | 12 | 4 | 4 | 8 | 8 | 10 | 4 | 1 | 1 | 0 | 1 | 4 | 1 |
| BUSY SLOTS: | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STALLS: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| PC | INSTRUCTION | F | D | P | I | X | W | C | Pi,Pj | Pk | Pl | IW# | OPCD | Pi | Pj | Pk | I/Pi | Cj | Ck | Cl | ROB# | PC | Ri | oPi | s | x | c | |
|------|--------------|---|---|---|---|---|---|---|-------|----|----|-----|------|----|----|----|------|----|----|----|------|----|----|-----|---|---|---|--|
| 000] | LW R2,0(R1) | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 001] | MUL R4,R2,R2 | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 002] | SW R4,0(R1) | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 003] | ADDI R1,R1,4 | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | |

----- Press ENTER to continue (PC=4,IC=4,CK=0,CTOT=1,IPC=4.00) ...

PHYSICAL REGS: 1 2 3 4 5 6 7 8

qi: 0 1 1 1 1 1 1 1
vi: 00 00 00 00 00 00 00 00

REG. FILE: Ri: 1 2 3 4 5 6 7 8
Pi: 4 1 1 0 1 0 0 0
Qi: 1 1 1 0 1 0 0 0
Vi: 00001000 00000000 00003000 00000000 00000000 00000000 00000003 00000000

| STAGES: | F | D | P | I | X | W | C | RENAMED-STR | INSTRUCTION-WINDOW | REORDER-BUFFER | A | M | L | S | B | F | X |
|--------------|---|---|---|---|----|---|---|-------------|--------------------|----------------|---|---|---|---|---|---|---|
| TOTAL SLOTS: | 4 | 4 | 8 | 4 | 12 | 4 | 4 | 8 | 8 | 10 | 4 | 1 | 1 | 0 | 1 | 4 | 1 |
| BUSY SLOTS: | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STALLS: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| PC | INSTRUCTION | F | D | P | I | X | W | C | RENAMED-STR | INSTRUCTION-WINDOW | REORDER-BUFFER | A | M | L | S | B | F | X | |
|------|--------------|---|---|---|---|---|---|---|-------------|--------------------|----------------|----|----|---|---|---|---|---|---|
| 000] | LW R2,0(R1) | 0 | 1 | 2 | | | | | P2,0(P1) | 000) | LW P2 P1 | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 001] | MUL R4,R2,R2 | 0 | 1 | 2 | | | | | P3,P2,P2 | 001) | MUL P3 P2 | P2 | - | 0 | 0 | 0 | 0 | 0 | 0 |
| 002] | SW R4,0(R1) | 0 | 1 | 2 | | | | | ,0(P1)<-P3 | 002) | SW - P3 | P1 | 0 | - | 2 | - | 0 | 0 | 0 |
| 003] | ADDI R1,R1,4 | 0 | 1 | 2 | | | | | P4,P1,4 | 003) | ADDI P4 P1 | - | 4 | 2 | - | - | 0 | 0 | 0 |
| 004] | BNE R2,R0,-5 | 1 | | 2 | | | | | ,P2,P0,-5 | 000) | BNE - P2 | P0 | -5 | - | 3 | - | 0 | 0 | 0 |

Press ENTER to continue (PC=0,IC=5,CK=1,CTOT=2,IPC=2.50)...

| PHYSICAL REGS: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|----------------|----|----|----|----|----|----|----|----|
| qi: | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| vi: | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 |

| REG.FILE: | Ri: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Pi: | 4 | 2 | | 3 | 3 | | | | |
| Qi: | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Vi: | 00001000 | 00000000 | 00003000 | 00000000 | 00000000 | 00000000 | 00000000 | 00000003 | 00000000 |

| STAGES: | F | D | P | I | X | W | C | RENAMED-STR | INSTRUCTION-WINDOW | REORDER-BUFFER | A | M | L | S | B | F | X |
|--------------|---|---|---|---|----|---|---|-------------|--------------------|----------------|---|---|---|---|---|---|---|
| TOTAL SLOTS: | 4 | 4 | 8 | 4 | 12 | 4 | 4 | 8 | 8 | 10 | 4 | 1 | 1 | 0 | 1 | 4 | 1 |
| BUSY SLOTS: | 4 | 1 | 4 | 0 | 0 | 0 | 0 | 4 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STALLS: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| PC | INSTRUCTION | F | D | P | I | X | W | C | RENAMED-STR | INSTRUCTION-WINDOW | REORDER-BUFFER | A | M | L | S | B | F | X | |
|------|--------------|---|---|---|---|---|---|---|-------------|--------------------|----------------|----|----|---|---|---|---|---|---|
| 000] | LW R2,0(R1) | 0 | 1 | 2 | | | | | P2,0(P1) | 000) | LW P2 P1 | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 001] | MUL R4,R2,R2 | 0 | 1 | 2 | | | | | P3,P2,P2 | 001) | MUL P3 P2 | P2 | - | 0 | 0 | 0 | 0 | 0 | 0 |
| 002] | SW R4,0(R1) | 0 | 1 | 2 | | | | | ,0(P1)<-P3 | 002) | SW - P3 | P1 | 0 | - | 2 | - | 0 | 0 | 0 |
| 003] | ADDI R1,R1,4 | 0 | 1 | 2 | | | | | P4,P1,4 | 003) | ADDI P4 P1 | - | 4 | 2 | - | - | 0 | 0 | 0 |
| 004] | BNE R2,R0,-5 | 1 | | 2 | | | | | ,P2,P0,-5 | 000) | BNE - P2 | P0 | -5 | - | 3 | - | 0 | 0 | 0 |
| 005] | LW R2,0(R1) | 2 | | | | | | | P5,0(P4) | 000) | LW P5 P4 | - | 0 | 4 | - | - | 0 | 0 | 0 |
| 006] | MUL R4,R2,R2 | 2 | | | | | | | P6,P5,P5 | 002) | MUL P6 P5 | P5 | P5 | - | 0 | - | 0 | 0 | 0 |
| 007] | SW R4,0(R1) | 2 | | | | | | | ,0(P4)<-P6 | 003) | SW - P6 | P4 | 0 | - | 4 | - | 0 | 0 | 0 |
| 008] | ADDI R1,R1,4 | 2 | | | | | | | P7,P4,4 | 004) | ADDI P7 P4 | - | 4 | 4 | - | - | 0 | 0 | 0 |
| 009] | BNE R2,R0,-5 | 3 | | | | | | | ,P5,P0,-5 | 000) | BNE - P2 | P0 | -5 | - | 3 | - | 0 | 0 | 0 |

Press ENTER to continue (PC=4,IC=9,CK=2,CTOT=3,IPC=3.00)...

| PHYSICAL REGS: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|----------------|----|----|----|----|----|----|----|----|
| qi: | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| vi: | 00 | 00 | 00 | 04 | 00 | 00 | 00 | 00 |

| REG.FILE: | Ri: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Pi: | 7 | 5 | | 6 | | | | | |
| Qi: | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Vi: | 00001000 | 00000000 | 00003000 | 00000000 | 00000000 | 00000000 | 00000000 | 00000003 | 00000000 |

| STAGES: | F | D | P | I | X | W | C | RENAMED-STR | INSTRUCTION-WINDOW | REORDER-BUFFER | A | M | L | S | B | F | X |
|--------------|---|---|---|---|----|---|---|-------------|--------------------|----------------|---|---|---|---|---|---|---|
| TOTAL SLOTS: | 4 | 4 | 8 | 4 | 12 | 4 | 4 | 8 | 8 | 10 | 4 | 1 | 1 | 0 | 1 | 4 | 1 |
| BUSY SLOTS: | 1 | 4 | 3 | 1 | 1 | 0 | 0 | 7 | 3 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STALLS: | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |

| PC | INSTRUCTION | F | D | P | I | X | W | C | RENAMED-STR | INSTRUCTION-WINDOW | REORDER-BUFFER | A | M | L | S | B | F | X | |
|------|--------------|---|---|---|---|---|---|---|-------------|--------------------|----------------|----|----|---|---|---|---|---|---|
| 000] | LW R2,0(R1) | 0 | 1 | 2 | 3 | | | | P2,0(P1) | 000> | LW P2 P1 | - | 0 | 2 | - | - | 0 | 0 | 0 |
| 001] | MUL R4,R2,R2 | 0 | 1 | 2 | | | | | P3,P2,P2 | 001) | MUL P3 P2 | P2 | - | 0 | 0 | 0 | 0 | 0 | |
| 002] | SW R4,0(R1) | 0 | 1 | 2 | | | | | ,0(P1)<-P3 | 002) | SW - P3 | P1 | 0 | - | 2 | - | 0 | 0 | |
| 003] | ADDI R1,R1,4 | 0 | 1 | 2 | 3 | 3 | | | P4,P1,4 | 003> | ADDI P4 P1 | - | 4 | 2 | - | - | 0 | 0 | |
| 004] | BNE R2,R0,-5 | 1 | 2 | 3 | | | | | ,P2,P0,-5 | 000) | BNE - P2 | P0 | -5 | - | 3 | - | 0 | 0 | |
| 005] | LW R2,0(R1) | 2 | 3 | | | | | | P5,0(P4) | 000) | LW P5 P4 | - | 0 | 4 | - | - | 0 | 0 | |
| 006] | MUL R4,R2,R2 | 2 | 3 | | | | | | P6,P5,P5 | 002) | MUL P6 P5 | P5 | P5 | - | 0 | - | 0 | 0 | |
| 007] | SW R4,0(R1) | 2 | 3 | | | | | | ,0(P4)<-P6 | 003) | SW - P6 | P4 | 0 | - | 4 | - | 0 | 0 | |
| 008] | ADDI R1,R1,4 | 2 | 3 | | | | | | P7,P4,4 | 004) | ADDI P7 P4 | - | 4 | 4 | - | - | 0 | 0 | |
| 009] | BNE R2,R0,-5 | 3 | | | | | | | ,P5,P0,-5 | 000) | BNE - P2 | P0 | -5 | - | 3 | - | 0 | 0 | |

Press ENTER to continue (PC=0,IC=10,CK=3,CTOT=4,IPC=2.50)...

@003 stall due to NO SLOTS when trying to move instruction MUL/001 from stage P to stage I.
@003 stall due to NO S-unit available
@003 stall due to NO SLOTS when trying to move instruction SW/002 from stage P to stage I.

| PHYSICAL REGS: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|----------------|----|----|----|----|----|----|----|----|
| qi: | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| vi: | 00 | 00 | 00 | 04 | 00 | 00 | 00 | 00 |

| REG.FILE: | Ri: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Pi: | 7 | 5 | | 6 | | | | | |
| Qi: | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Vi: | 00001004 | 00000000 | 00003000 | 00000000 | 00000000 | 00000000 | 00000000 | 00000003 | 00000000 |

| STAGES: | F | D | P | I | X | W | C | RENAMED-STR | INSTRUCTION-WINDOW | REORDER-BUFFER | A | M | L | S | B | F | X |
|--------------|---|---|---|---|----|---|---|-------------|--------------------|----------------|---|---|---|---|---|---|---|
| TOTAL SLOTS: | 4 | 4 | 8 | 4 | 12 | 4 | 4 | 8 | 8 | 10 | 4 | 1 | 1 | 0 | 1 | 4 | 1 |
| BUSY SLOTS: | 4 | 1 | 5 | 1 | 2 | 1 | 0 | 7 | 5 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STALLS: | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |

| PC | INSTRUCTION | F | D | P | I | X | W | C | RENAMED-STR | INSTRUCTION-WINDOW | REORDER-BUFFER | A | M | L | S | B | F | X |
|------|--------------|---|---|---|---|---|---|---|-------------|--------------------|----------------|----|----|---|---|---|---|---|
| 000] | LW R2,0(R1) | 0 | 1 | 2 | 3 | 4 | | | P2,0(P1) | 000) | LW P2 P1 | - | 0 | 2 | - | - | 0 | 0 |
| 001] | MUL R4,R2,R2 | 0 | 1 | 2 | | | | | P3,P2,P2 | 001) | MUL P3 P2 | P2 | - | 0 | 0 | 0 | 0 | 0 |
| 002] | SW R4,0(R1) | 0 | 1 | 2 | 4 | | | | ,0(P1)<-P3 | 002> | SW - P3 | P1 | 0 | - | 2 | - | 0 | 0 |
| 003] | ADDI R1,R1,4 | 0 | 1 | 2 | 3 | 3 | 4 | | P4,P1,4 | 003> | ADDI P4 P1 | - | 4 | 2 | - | - | 0 | 0 |
| 004] | BNE R2,R0,-5 | 1 | 2 | 3 | 4 | 4 | | | ,P2,P0,-5 | 000> | BNE - P2 | P0 | -5 | - | 3 | - | 0 | 0 |
| 005] | LW R2,0(R1) | 2 | 3 | 4 | | | | | P5,0(P4) | 000) | LW P5 P4 | - | 0 | 4 | - | - | 0 | 0 |
| 006] | MUL R4,R2,R2 | 2 | 3 | 4 | | | | | P6,P5,P5 | 002) | MUL P6 P5 | P5 | P5 | - | 0 | - | 0 | 0 |
| 007] | SW R4,0(R1) | 2 | 3 | 4 | | | | | ,0(P4)<-P6 | 003) | SW - P6 | P4 | 0 | - | 4 | - | 0 | 0 |
| 008] | ADDI R1,R1,4 | 2 | 3 | 4 | | | | | P7,P4,4 | 004) | ADDI P7 P4 | - | 4 | 4 | - | - | 0 | 0 |
| 009] | BNE R2,R0,-5 | 3 | 4 | | | | | | ,P5,P0,-5 | 000) | BNE - P2 | P0 | -5 | - | 3 | - | 0 | 0 |
| 010] | LW R2,0(R1) | 4 | | | | | | | | | | | | | | | | |
| 011] | MUL R4,R2,R2 | 4 | | | | | | | | | | | | | | | | |
| 012] | SW R4,0(R1) | 4 | | | | | | | | | | | | | | | | |
| 013] | ADDI R1,R1,4 | 4 | | | | | | | | | | | | | | | | |

Press ENTER to continue (PC=4,IC=14,CK=4,CTOT=5,IPC=2.80)...

@004 stall due to NO SLOTS when trying to move instruction MUL/001 from stage P to stage I.

| PHYSICAL REGS: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|----------------|----|----|----|----|----|----|----|----|
| qi: | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| vi: | 00 | 00 | 00 | 04 | 00 | 00 | 08 | 00 |

| REG.FILE: | Ri: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Pi: | 7 | 8 | | 6 | | | | | |
| Qi: | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Vi: | 00001004 | 00000000 | 00003000 | 00000000 | 00000000 | 00000000 | 00000000 | 00000003 | 00000000 |

| STAGES: | F | D | P | I | X | W | C | RENAMED-STR | INSTRUCTION-WINDOW | REORDER-BUFFER | A | M | L | S |
|---------|---|---|---|---|---|---|---|-------------|--------------------|----------------|---|---|---|---|
|---------|---|---|---|---|---|---|---|-------------|--------------------|----------------|---|---|---|---|

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| BUSY SLOTS: | 4 | 1 | 4 | 1 | 2 | 1 | 0 | 8 | 4 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | | |
|-------------------|---|---|---|---|---|---|---|-------------|-----------|------|------|----|----|------|----|----|----|------|------|-----|-----|---|---|---|---|
| STALLS: | 0 | 1 | 0 | 6 | 0 | 0 | 1 | 1 | 4 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | | | | | | | | | |
| PC INSTRUCTION | F | D | P | I | X | W | C | Pi,Pj Pk Pl | IW# | OPCD | Pi | Pj | Pk | I/Pi | Cj | Ck | Cl | ROB# | PC | Ri | oPi | s | x | c | |
| 000] LW R2,0(R1) | 0 | 1 | 2 | 3 | 4 | | | P2,0(P1) | ---- | LW | P2 | P1 | - | 0 | 2 | - | - | 000) | 000 | R2 | - | 0 | 0 | 0 | |
| 001] MUL R4,R2,R2 | 0 | 1 | 2 | 6 | 6 | | | P3,P2,P2 | 001> | MUL | P3 | P2 | P2 | - | 6 | 6 | - | 001) | 001 | R4 | - | 0 | 0 | 0 | |
| 002] SW R4,0(R1) | 0 | 1 | 2 | 4 | 5 | | | ,0(P1)<-P3 | ---- | SW | - | P3 | P1 | 0 | - | 2 | - | 002) | 002 | - | - | 1 | 0 | 0 | |
| 003] ADDI R1,R1,4 | 0 | 1 | 2 | 3 | 3 | 4 | | | P4,P1,4 | ---- | ADDI | P4 | P1 | - | 4 | 2 | - | 003) | 003 | R1 | P1 | 0 | 0 | 1 | |
| 004] BNE R2,R0,-5 | 1 | 2 | 3 | 4 | 4 | 5 | | | ,P2,P0,-5 | ---- | BNE | - | P2 | P0 | -5 | - | 3 | - | 004) | 004 | - | - | 0 | 0 | 1 |
| 005] LW R2,0(R1) | 2 | 3 | 4 | 5 | 6 | | | P5,0(P4) | 000> | LW | P5 | P4 | - | 0 | 4 | - | - | 005) | 000 | R2 | P2 | 0 | 0 | 0 | |
| 006] MUL R4,R2,R2 | 2 | 3 | 4 | 6 | 6 | | | P6,P5,P5 | 002) | MUL | P6 | P5 | P5 | - | - | - | - | 006) | 001 | R4 | P3 | 0 | 0 | 0 | |
| 007] SW R4,0(R1) | 2 | 3 | 4 | 6 | 6 | | | ,0(P4)<-P6 | 003) | SW | - | P6 | P4 | 0 | - | 4 | - | 007) | 002 | - | - | 1 | 0 | 0 | |
| 008] ADDI R1,R1,4 | 2 | 3 | 4 | 5 | 5 | | | P7,P4,4 | 004> | ADDI | P7 | P4 | - | 4 | 4 | - | - | 008) | 003 | R1 | P4 | 0 | 0 | 0 | |
| 009] BNE R2,R0,-5 | 3 | 4 | 5 | 6 | 6 | | | ,P5,P0,-5 | 000) | BNE | - | P5 | P0 | -5 | - | 5 | - | 009) | 004 | - | - | 0 | 0 | 0 | |
| 010] LW R2,0(R1) | 4 | 5 | 6 | 7 | 7 | | | P8,0(P7) | | | | | | | | | | | | | | | | | |
| 011] MUL R4,R2,R2 | 4 | | | | | | | | | | | | | | | | | | | | | | | | |
| 012] SW R4,0(R1) | 4 | | | | | | | | | | | | | | | | | | | | | | | | |
| 013] ADDI R1,R1,4 | 4 | | | | | | | | | | | | | | | | | | | | | | | | |
| 014] BNE R2,R0,-5 | 5 | | | | | | | | | | | | | | | | | | | | | | | | |

Press ENTER to continue (PC=6,IC=15,CK=5,CTOT=6,IPC=2.50)...

@005 stall due to NO SLOTS when trying to move instnction ADDI/003 from stage W to stage C.
 @005 stall due to NO SLOTS when trying to move instnction MUL/001 from stage P to stage I.
 @005 stall due to NO SLOTS when trying to move instnction MUL/006 from stage P to stage I.
 @005 stall due to no S-unit available
 @005 stall due to NO SLOTS when trying to move instnction SW/007 from stage P to stage I.
 @005 stall due to Physical registers not available
 @005 stall due to NO SLOTS when trying to move instnction MUL/011 from stage F to stage D.

| PHYSICAL REGS: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|----------------|----|----|----|----|----|----|----|----|
| qi: | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| vi: | 00 | 00 | 00 | 04 | 00 | 00 | 08 | 00 |

| REG.FILE: | Ri: | Pi: | Qi: | Vi: |
|-----------|----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 |
| | 7 | 8 | 6 | 5 |
| | 0 | 1 | 0 | 0 |
| | 00001008 | 00000000 | 00003000 | 00000000 |
| | 00000000 | 00000000 | 00000000 | 00000003 |
| | 00000000 | 00000003 | 00000000 | 00000000 |

| STAGES: | F | D | P | I | X | W | C | RENAMED-STR | INSTRUCTION-WINDOW | REORDER-BUFFER | A | M | L | S | B | F | X |
|--------------|---|---|---|---|----|---|---|-------------|--------------------|----------------|---|---|---|---|---|---|---|
| TOTAL SLOTS: | 4 | 4 | 8 | 4 | 12 | 4 | 4 | 8 | 8 | 10 | 4 | 1 | 1 | 0 | 1 | 4 | 1 |
| BUSY SLOTS: | 4 | 1 | 1 | 1 | 3 | 1 | 0 | 8 | 1 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STALLS: | 0 | 2 | 1 | 7 | 0 | 0 | 2 | 2 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|-------------------|---|---|---|---|---|---|---|-------------|-----------|------|------|----|----|------|----|----|----|------|------|-----|-----|---|---|---|---|
| PC INSTRUCTION | F | D | P | I | X | W | C | Pi,Pj Pk Pl | IW# | OPCD | Pi | Pj | Pk | I/Pi | Cj | Ck | Cl | ROB# | PC | Ri | oPi | s | x | c | |
| 000] LW R2,0(R1) | 0 | 1 | 2 | 3 | 4 | 6 | | | P2,0(P1) | ---- | LW | P2 | P1 | - | 0 | 2 | - | 000) | 000 | R2 | - | 0 | 0 | 1 | |
| 001] MUL R4,R2,R2 | 0 | 1 | 2 | 6 | 6 | | | P3,P2,P2 | 001> | MUL | P3 | P2 | P2 | - | 6 | 6 | - | 001) | 001 | R4 | - | 0 | 0 | 0 | |
| 002] SW R4,0(R1) | 0 | 1 | 2 | 4 | 5 | | | ,0(P1)<-P3 | ---- | SW | - | P3 | P1 | 0 | - | 2 | - | 002) | 002 | - | - | 1 | 0 | 0 | |
| 003] ADDI R1,R1,4 | 0 | 1 | 2 | 3 | 3 | 4 | | | P4,P1,4 | ---- | ADDI | P4 | P1 | - | 4 | 2 | - | 003) | 003 | R1 | P1 | 0 | 0 | 1 | |
| 004] BNE R2,R0,-5 | 1 | 2 | 3 | 4 | 4 | 5 | | | ,P2,P0,-5 | ---- | BNE | - | P2 | P0 | -5 | - | 3 | - | 004) | 004 | - | - | 0 | 0 | 1 |
| 005] LW R2,0(R1) | 2 | 3 | 4 | 5 | 6 | | | P5,0(P4) | 000> | LW | P5 | P4 | - | 0 | 4 | - | - | 005) | 000 | R2 | P2 | 0 | 0 | 0 | |
| 006] MUL R4,R2,R2 | 2 | 3 | 4 | 6 | 6 | | | P6,P5,P5 | 002) | MUL | P6 | P5 | P5 | - | - | - | - | 006) | 001 | R4 | P3 | 0 | 0 | 0 | |
| 007] SW R4,0(R1) | 2 | 3 | 4 | 6 | 6 | | | ,0(P4)<-P6 | 003> | SW | - | P6 | P4 | 0 | - | 4 | - | 007) | 002 | - | - | 1 | 0 | 0 | |
| 008] ADDI R1,R1,4 | 2 | 3 | 4 | 5 | 5 | 6 | | | P7,P4,4 | ---- | ADDI | P7 | P4 | - | 4 | 4 | - | 008) | 003 | R1 | P4 | 0 | 0 | 1 | |
| 009] BNE R2,R0,-5 | 3 | 4 | 5 | 6 | 6 | | | ,P5,P0,-5 | 000> | BNE | - | P5 | P0 | -5 | - | 5 | - | 009) | 004 | - | - | 0 | 0 | 0 | |
| 010] LW R2,0(R1) | 4 | 5 | 6 | 7 | 7 | | | P8,0(P7) | | | | | | | | | | | | | | | | | |
| 011] MUL R4,R2,R2 | 4 | | | | | | | | | | | | | | | | | | | | | | | | |
| 012] SW R4,0(R1) | 4 | | | | | | | | | | | | | | | | | | | | | | | | |
| 013] ADDI R1,R1,4 | 4 | | | | | | | | | | | | | | | | | | | | | | | | |
| 014] BNE R2,R0,-5 | 5 | | | | | | | | | | | | | | | | | | | | | | | | |

Press ENTER to continue (PC=6,IC=15,CK=6,CTOT=7,IPC=2.14)...

@006 stall due to NO SLOTS when trying to move instnction BNE/004 from stage W to stage C.
 @006 stall due to NO SLOTS when trying to move instnction MUL/006 from stage P to stage I.
 @006 stall due to ROB full
 @006 stall due to NO SLOTS when trying to move instnction LW/010 from stage D to stage P.
 @006 stall due to Physical registers not available
 @006 stall due to NO SLOTS when trying to move instnction MUL/011 from stage F to stage D.

| PHYSICAL REGS: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|----------------|----|----|----|----|----|----|----|----|
| qi: | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| vi: | 00 | 00 | 00 | 04 | 00 | 00 | 08 | 00 |

| REG.FILE: | Ri: | Pi: | Qi: | Vi: |
|-----------|----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 |
| | 7 | 8 | 6 | 5 |
| | 0 | 1 | 0 | 0 |
| | 00001008 | 00000000 | 00003000 | 00000000 |
| | 00000000 | 00000000 | 00000000 | 00000003 |
| | 00000000 | 00000003 | 00000000 | 00000000 |

| STAGES: | F | D | P | I | X | W | C | RENAMED-STR | INSTRUCTION-WINDOW | REORDER-BUFFER | A | M | L | S | B | F | X |
|--------------|---|---|---|---|----|---|---|-------------|--------------------|----------------|---|---|---|---|---|---|---|
| TOTAL SLOTS: | 4 | 4 | 8 | 4 | 12 | 4 | 4 | 8 | 8 | 10 | 4 | 1 | 1 | 0 | 1 | 4 | 1 |
| BUSY SLOTS: | 4 | 0 | 2 | 0 | 2 | 1 | 0 | 8 | 2 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STALLS: | 0 | 3 | 1 | 8 | 0 | 0 | 2 | 3 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|-------------------|---|---|---|---|---|---|---|-------------|-----------|------|------|----|----|------|----|----|----|------|------|-----|-----|---|---|---|---|
| PC INSTRUCTION | F | D | P | I | X | W | C | Pi,Pj Pk Pl | IW# | OPCD | Pi | Pj | Pk | I/Pi | Cj | Ck | Cl | ROB# | PC | Ri | oPi | s | x | c | |
| 000] LW R2,0(R1) | 0 | 1 | 2 | 3 | 4 | 6 | | | P2,0(P1) | ---- | LW | P2 | P1 | - | 0 | 2 | - | 000) | 000 | R2 | - | 0 | 0 | 1 | |
| 001] MUL R4,R2,R2 | 0 | 1 | 2 | 6 | 6 | | | P3,P2,P2 | 001> | MUL | P3 | P2 | P2 | - | 6 | 6 | - | 001) | 001 | R4 | - | 0 | 0 | 0 | |
| 002] SW R4,0(R1) | 0 | 1 | 2 | 4 | 5 | | | ,0(P1)<-P3 | ---- | SW | - | P3 | P1 | 0 | - | 2 | - | 002) | 002 | - | - | 1 | 0 | 0 | |
| 003] ADDI R1,R1,4 | 0 | 1 | 2 | 3 | 3 | 4 | | | P4,P1,4 | ---- | ADDI | P4 | P1 | - | 4 | 2 | - | 003) | 003 | R1 | P1 | 0 | 0 | 1 | |
| 004] BNE R2,R0,-5 | 1 | 2 | 3 | 4 | 4 | 5 | | | ,P2,P0,-5 | ---- | BNE | - | P2 | P0 | -5 | - | 3 | - | 004) | 004 | - | - | 0 | 0 | 1 |
| 005] LW R2,0(R1) | 2 | 3 | 4 | 5 | 6 | | | P5,0(P4) | 000> | LW | P5 | P4 | - | 0 | 4 | - | - | 005) | 000 | R2 | P2 | 0 | 0 | 0 | |
| 006] MUL R4,R2,R2 | 2 | 3 | 4 | 6 | 6 | | | P6,P5,P5 | 002) | MUL | P6 | P5 | P5 | - | - | - | - | 006) | 001 | R4 | P3 | 0 | 0 | 0 | |
| 007] SW R4,0(R1) | 2 | 3 | 4 | 6 | 6 | | | ,0(P4)<-P6 | 003> | SW | - | P6 | P4 | 0 | - | 4 | - | 007) | 002 | - | - | 1 | 0 | 0 | |
| 008] ADDI R1,R1,4 | 2 | 3 | 4 | 5 | 5 | 6 | | | P7,P4,4 | ---- | ADDI | P7 | P4 | - | 4 | 4 | - | 008) | 003 | R1 | P4 | 0 | 0 | 1 | |
| 009] BNE R2,R0,-5 | 3 | 4 | 5 | 6 | 6 | | | ,P5,P0,-5 | 000> | BNE | - | P5 | P0 | -5 | - | 5 | - | 009) | 004 | - | - | 0 | 0 | 0 | |
| 010] LW R2,0(R1) | 4 | 5 | 6 | 7 | 7 | | | P8,0(P7) | 000) | LW | P8 | P7 | - | 0 | 7 | - | - | 000) | 000 | R2 | P5 | 0 | 0 | 0 | |
| 011] MUL R4,R2,R2 | 4 | | | | | | | | | | | | | | | | | | | | | | | | |
| 012] SW R4,0(R1) | 4 | | | | | | | | | | | | | | | | | | | | | | | | |
| 013] ADDI R1,R1,4 | 4 | | | | | | | | | | | | | | | | | | | | | | | | |
| 014] BNE R2,R0,-5 | 5 | | | | | | | | | | | | | | | | | | | | | | | | |

Press ENTER to continue (PC=6,IC=15,CK=7,CTOT=8,IPC=1.88)...

@007 stall due to NO SLOTS when trying to move instnction MUL/006 from stage P to stage I.
 @007 stall due to Physical registers not available
 @007 stall due to NO SLOTS when trying to move instnction MUL/011 from stage F to stage D.

| PHYSICAL REGS: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|----------------|----|----|----|----|----|----|---|---|
| qi: | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| vi: | 00 | 00 | 00 | 04 | 00 | 00 | | |

| PC | INSTRUCTION | F | D | P | I | X | W | C | Pi,Pj | Pk | P1 | IW# | OPCD | Pi | Pj | Pk | I/P1 | Cj | Ck | Cl | ROB# | PC | Ri | oPi | s | x | c | |
|------|--------------|---|---|---|---|---|---|---|-----------|----|----|------|------|----|----|----|------|----|----|-----|------|-----|-----|-----|---|---|-------|-------|
| 000] | LW R2,0(R1) | 0 | 1 | 2 | 3 | 4 | 6 | 7 | P2,0(P1) | | | --- | LW | P2 | P1 | - | 0 | 2 | - | - | --- | 000 | R2 | - | 0 | 0 | 1 | LQ(1) |
| 001] | MUL R4,R2,R2 | 0 | 1 | 2 | 6 | 6 | | | P3,P2,P2 | | | --- | MUL | P3 | P2 | P2 | - | 6 | 6 | - | --- | 001 | R4 | - | 0 | 0 | 0 | PC |
| 002] | SW R4,0(R1) | 0 | 1 | 2 | 4 | 5 | | | 0(P1)<-P3 | | | --- | SW | - | P3 | P1 | 0 | - | 2 | - | --- | 002 | 002 | - | 1 | 0 | 0 | --- |
| 003] | ADDI R1,R1,4 | 0 | 1 | 2 | 3 | 3 | 4 | | P4,P1,4 | | | --- | ADDI | P4 | P1 | - | 4 | 2 | - | --- | 003 | R1 | P1 | 0 | 0 | 1 | --- | |
| 004] | BNE R2,R0,-5 | 1 | 2 | 3 | 4 | 4 | 5 | | P2,P0,-5 | | | --- | BNE | - | P2 | P0 | -5 | - | 3 | - | --- | 004 | 004 | - | 0 | 0 | 1 | 010] |
| 005] | LW R2,0(R1) | 2 | 3 | 4 | 5 | 6 | 8 | | P5,0(P4) | | | --- | LW | P5 | P4 | - | 0 | 4 | - | --- | 005 | R2 | P2 | 0 | 0 | 1 | --- | |
| 006] | MUL R4,R2,R2 | 2 | 3 | 4 | 8 | 8 | | | P6,P5,P5 | | | 002> | MUL | P6 | P5 | P5 | - | 8 | 8 | - | --- | 006 | R4 | P3 | 0 | 0 | 0 | --- |
| 007] | SW R4,0(R1) | 2 | 3 | 4 | 6 | 7 | | | 0(P4)<-P6 | | | --- | SW | - | P6 | P4 | 0 | - | 4 | - | --- | 007 | 002 | - | 1 | 0 | 0 | --- |
| 008] | ADDI R1,R1,4 | 2 | 3 | 4 | 5 | 5 | 6 | | P7,P4,4 | | | --- | ADDI | P7 | P4 | - | 4 | 4 | - | --- | 008 | R1 | P4 | 0 | 0 | 1 | SQ(2) | |
| 009] | BNE R2,R0,-5 | 3 | 4 | 5 | 6 | 6 | 7 | | P5,P0,-5 | | | --- | BNE | - | P5 | P0 | -5 | - | 5 | - | --- | 009 | 004 | - | 0 | 0 | 1 | --- |
| 010] | LW R2,0(R1) | 4 | 5 | 7 | 8 | 7 | | | P8,0(P7) | | | 000> | LW | P8 | P7 | - | 0 | 7 | - | --- | 000 | R2 | P5 | 0 | 0 | 0 | --- | |

Press ENTER to continue (PC=6,IC=15,CK=8,CTOT=9,IPC=1.67)...

@008 stall due to NO SLOTS when trying to move instnction BNE/009 from stage W to stage C.
@008 stall due to Physical registers not available
@008 stall due to NO SLOTS when trying to move instnction MUL/011 from stage F to stage D.

| | | | | | | | | |
|----------------|----|----|----|----|----|----|----|----|
| PHYSICAL REGS: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| qi: | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| vi: | 00 | 00 | 00 | 04 | 00 | 00 | 08 | 00 |

| | | | | | | | | | |
|-----------|-----|----------|----------|----------|----------|----------|----------|----------|----------|
| REG.FILE: | Ri: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | Pi: | 7 | 8 | - | 6 | - | - | - | - |
| | Qi: | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| | Vi: | 00001008 | 00000000 | 00003000 | 00000000 | 00000000 | 00000000 | 00000003 | 00000000 |

| STAGES: | F | D | P | I | X | W | C | RENAMED-STR | INSTRUCTION-WINDOW | REORDER-BUFFER | A | M | L | S | B | F | X |
|--------------|---|---|---|---|----|---|---|-------------|--------------------|----------------|---|---|---|---|---|---|---|
| TOTAL SLOTS: | 4 | 4 | 8 | 4 | 12 | 4 | 4 | 8 | 8 | 10 | 4 | 1 | 1 | 0 | 1 | 4 | 1 |
| BUSY SLOTS: | 4 | 0 | 0 | 0 | 3 | 1 | 0 | 8 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STALLS: | 0 | 5 | 1 | 8 | 0 | 0 | 4 | 5 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | |

| PC | INSTRUCTION | F | D | P | I | X | W | C | Pi,Pj | Pk | P1 | IW# | OPCD | Pi | Pj | Pk | I/P1 | Cj | Ck | Cl | ROB# | PC | Ri | oPi | s | x | c | |
|------|--------------|---|---|---|---|---|---|---|-----------|----|----|-----|------|----|----|----|------|----|----|-----|------|-----|-----|-----|---|---|-------|-------|
| 000] | LW R2,0(R1) | 0 | 1 | 2 | 3 | 4 | 6 | 7 | P2,0(P1) | | | --- | LW | P2 | P1 | - | 0 | 2 | - | - | --- | 000 | R2 | - | 0 | 0 | 1 | LQ(1) |
| 001] | MUL R4,R2,R2 | 0 | 1 | 2 | 6 | 6 | | | P3,P2,P2 | | | --- | MUL | P3 | P2 | P2 | - | 6 | 6 | - | --- | 001 | R4 | - | 0 | 0 | 0 | PC |
| 002] | SW R4,0(R1) | 0 | 1 | 2 | 4 | 5 | | | 0(P1)<-P3 | | | --- | SW | - | P3 | P1 | 0 | - | 2 | - | --- | 002 | 002 | - | 1 | 0 | 0 | --- |
| 003] | ADDI R1,R1,4 | 0 | 1 | 2 | 3 | 3 | 4 | | P4,P1,4 | | | --- | ADDI | P4 | P1 | - | 4 | 2 | - | --- | 003 | R1 | P1 | 0 | 0 | 1 | --- | |
| 004] | BNE R2,R0,-5 | 1 | 2 | 3 | 4 | 4 | 5 | | P2,P0,-5 | | | --- | BNE | - | P2 | P0 | -5 | - | 3 | - | --- | 004 | 004 | - | 0 | 0 | 1 | 010] |
| 005] | LW R2,0(R1) | 2 | 3 | 4 | 5 | 6 | 8 | | P5,0(P4) | | | --- | LW | P5 | P4 | - | 0 | 4 | - | --- | 005 | R2 | P2 | 0 | 0 | 1 | --- | |
| 006] | MUL R4,R2,R2 | 2 | 3 | 4 | 8 | 8 | | | P6,P5,P5 | | | --- | MUL | P6 | P5 | P5 | - | 8 | 8 | - | --- | 006 | R4 | P3 | 0 | 0 | 0 | --- |
| 007] | SW R4,0(R1) | 2 | 3 | 4 | 6 | 7 | | | 0(P4)<-P6 | | | --- | SW | - | P6 | P4 | 0 | - | 4 | - | --- | 007 | 002 | - | 1 | 0 | 0 | --- |
| 008] | ADDI R1,R1,4 | 2 | 3 | 4 | 5 | 5 | 6 | | P7,P4,4 | | | --- | ADDI | P7 | P4 | - | 4 | 4 | - | --- | 008 | R1 | P4 | 0 | 0 | 1 | SQ(2) | |
| 009] | BNE R2,R0,-5 | 3 | 4 | 5 | 6 | 6 | 7 | | P5,P0,-5 | | | --- | BNE | - | P5 | P0 | -5 | - | 5 | - | --- | 009 | 004 | - | 0 | 0 | 1 | --- |
| 010] | LW R2,0(R1) | 4 | 5 | 7 | 8 | 9 | | | P8,0(P7) | | | --- | LW | P8 | P7 | - | 0 | 7 | - | --- | 000 | R2 | P5 | 0 | 0 | 0 | --- | |

Press ENTER to continue (PC=6,IC=15,CK=9,CTOT=10,IPC=1.50)...

@009 stall due to NO SLOTS when trying to move instnction LW/005 from stage W to stage C.
@009 stall due to Physical registers not available
@009 stall due to NO SLOTS when trying to move instnction MUL/011 from stage F to stage D.

| | | | | | | | | |
|----------------|----|----|----|----|----|----|----|----|
| PHYSICAL REGS: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| qi: | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| vi: | 00 | 00 | 00 | 04 | 00 | 00 | 08 | 00 |

| | | | | | | | | | |
|-----------|-----|----------|----------|----------|----------|----------|----------|----------|----------|
| REG.FILE: | Ri: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | Pi: | 7 | 8 | - | 6 | - | - | - | - |
| | Qi: | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| | Vi: | 00001008 | 00000000 | 00003000 | 00000000 | 00000000 | 00000000 | 00000003 | 00000000 |

| STAGES: | F | D | P | I | X | W | C | RENAMED-STR | INSTRUCTION-WINDOW | REORDER-BUFFER | A | M | L | S | B | F | X |
|--------------|---|---|---|---|----|---|---|-------------|--------------------|----------------|---|---|---|---|---|---|---|
| TOTAL SLOTS: | 4 | 4 | 8 | 4 | 12 | 4 | 4 | 8 | 8 | 10 | 4 | 1 | 1 | 0 | 1 | 4 | 1 |
| BUSY SLOTS: | 4 | 0 | 0 | 0 | 3 | 1 | 0 | 8 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STALLS: | 0 | 6 | 1 | 8 | 0 | 0 | 5 | 6 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | |

| PC | INSTRUCTION | F | D | P | I | X | W | C | Pi,Pj | Pk | P1 | IW# | OPCD | Pi | Pj | Pk | I/P1 | Cj | Ck | Cl | ROB# | PC | Ri | oPi | s | x | c | |
|------|--------------|---|---|---|---|---|---|---|-----------|----|----|-----|------|----|----|----|------|----|----|-----|------|-----|-----|-----|---|---|-------|-------|
| 000] | LW R2,0(R1) | 0 | 1 | 2 | 3 | 4 | 6 | 7 | P2,0(P1) | | | --- | LW | P2 | P1 | - | 0 | 2 | - | - | --- | 000 | R2 | - | 0 | 0 | 1 | LQ(1) |
| 001] | MUL R4,R2,R2 | 0 | 1 | 2 | 6 | 6 | | | P3,P2,P2 | | | --- | MUL | P3 | P2 | P2 | - | 6 | 6 | - | --- | 001 | R4 | - | 0 | 0 | 0 | PC |
| 002] | SW R4,0(R1) | 0 | 1 | 2 | 4 | 5 | | | 0(P1)<-P3 | | | --- | SW | - | P3 | P1 | 0 | - | 2 | - | --- | 002 | 002 | - | 1 | 0 | 0 | --- |
| 003] | ADDI R1,R1,4 | 0 | 1 | 2 | 3 | 3 | 4 | | P4,P1,4 | | | --- | ADDI | P4 | P1 | - | 4 | 2 | - | --- | 003 | R1 | P1 | 0 | 0 | 1 | --- | |
| 004] | BNE R2,R0,-5 | 1 | 2 | 3 | 4 | 4 | 5 | | P2,P0,-5 | | | --- | BNE | - | P2 | P0 | -5 | - | 3 | - | --- | 004 | 004 | - | 0 | 0 | 1 | 010] |
| 005] | LW R2,0(R1) | 2 | 3 | 4 | 5 | 6 | 8 | | P5,0(P4) | | | --- | LW | P5 | P4 | - | 0 | 4 | - | --- | 005 | R2 | P2 | 0 | 0 | 1 | --- | |
| 006] | MUL R4,R2,R2 | 2 | 3 | 4 | 8 | 8 | | | P6,P5,P5 | | | --- | MUL | P6 | P5 | P5 | - | 8 | 8 | - | --- | 006 | R4 | P3 | 0 | 0 | 0 | --- |
| 007] | SW R4,0(R1) | 2 | 3 | 4 | 6 | 7 | | | 0(P4)<-P6 | | | --- | SW | - | P6 | P4 | 0 | - | 4 | - | --- | 007 | 002 | - | 1 | 0 | 0 | --- |
| 008] | ADDI R1,R1,4 | 2 | 3 | 4 | 5 | 5 | 6 | | P7,P4,4 | | | --- | ADDI | P7 | P4 | - | 4 | 4 | - | --- | 008 | R1 | P4 | 0 | 0 | 1 | SQ(2) | |
| 009] | BNE R2,R0,-5 | 3 | 4 | 5 | 6 | 6 | 7 | | P5,P0,-5 | | | --- | BNE | - | P5 | P0 | -5 | - | 5 | - | --- | 009 | 004 | - | 0 | 0 | 1 | --- |
| 010] | LW R2,0(R1) | 4 | 5 | 7 | 8 | 9 | | | P8,0(P7) | | | --- | LW | P8 | P7 | - | 0 | 7 | - | --- | 000 | R2 | P5 | 0 | 0 | 0 | --- | |

Press ENTER to continue (PC=6,IC=15,CK=10,CTOT=11,IPC=1.36)...

@010 stall due to NO SLOTS when trying to move instnction LW/005 from stage W to stage C.
@010 stall due to Physical registers not available
@010 stall due to NO SLOTS when trying to move instnction MUL/011 from stage F to stage D.

| | | | | | | | | |
|----------------|----|----|----|----|----|----|----|----|
| PHYSICAL REGS: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| qi: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| vi: | 00 | 00 | 00 | 04 | 00 | 00 | 08 | 00 |

| | | | | | | | | | |
|-----------|-----|----------|----------|----------|----------|----------|----------|----------|----------|
| REG.FILE: | Ri: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | Pi: | 7 | 8 | - | 6 | - | - | - | - |
| | Qi: | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | Vi: | 00001008 | 00000000 | 00003000 | 00000000 | 00000000 | 00000000 | 00000003 | 00000000 |

| STAGES: | F | D | P | I | X | W | C | RENAMED-STR | INSTRUCTION-WINDOW | REORDER-BUFFER | A | M | L | S | B | F | X |
|--------------|---|---|---|---|----|---|---|-------------|--------------------|----------------|---|---|---|---|---|---|---|
| TOTAL SLOTS: | 4 | 4 | 8 | 4 | 12 | 4 | 4 | 8 | 8 | 10 | 4 | 1 | 1 | 0 | 1 | 4 | 1 |
| BUSY SLOTS: | 4 | 0 | 0 | 0 | 1 | 1 | 0 | 8 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STALLS: | 0 | 7 | 1 | 8 | 0 | 0 | 6 | 7 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | |

| PC | INSTRUCTION | F | D | P | I | X | W | C | Pi,Pj | Pk | P1 | IW# | OPCD | Pi | Pj | Pk | I/P1 | Cj | Ck | Cl | ROB# | PC | Ri | oPi | s | x | c |
|----|-------------|---|---|---|---|---|---|---|-------|----|----|-----|------|----|----|----|------|----|----|----|------|----|----|-----|---|---|---|
|----|-------------|---|---|---|---|---|---|---|-------|----|----|-----|------|----|----|----|------|----|----|----|------|----|----|-----|---|---|---|

Pi: 2 8 0 1 0 0 0 0
Qi: 1 0 0 0 0 0 0 0 0
Vi: 00001004 00000000 00003000 00000000 00000000 00000000 00000003 00000000

Table with 10 columns: STAGES, TOTAL SLOTS, BUSY SLOTS, STALLS, F, D, P, I, X, W, C, RENAMED-STR, INSTRUCTION-WINDOW, REORDER-BUFFER, A, M, L, S, B, F, X

PC INSTRUCTION table with columns: PC, INSTRUCTION, F, D, P, I, X, W, C, P1, Pj, Pk, P1, IW#, OPCD, P1, Pj, Pk, I/P1, Cj, Ck, Cl, ROB#, PC, R1, oP1, s, x, c. Includes instructions like LW R2,0(R1), MUL R4,R2,R2, SW R4,0(R1), etc.

PHYSICAL REGS: 1 2 3 4 5 6 7 8
qi: 1 0 1 1 1 0 0 0
vi: 00 04 00 04 00 00 00 00

REG.FILE: Ri: 1 2 3 4 5 6 7 8
Pi: 2 8 0 1 0 0 0 0
Qi: 0 0 0 0 0 0 0 0
Vi: 00001004 00000000 00003000 00000000 00000000 00000000 00000003 00000000

Table with 10 columns: STAGES, TOTAL SLOTS, BUSY SLOTS, STALLS, F, D, P, I, X, W, C, RENAMED-STR, INSTRUCTION-WINDOW, REORDER-BUFFER, A, M, L, S, B, F, X

PC INSTRUCTION table with columns: PC, INSTRUCTION, F, D, P, I, X, W, C, P1, Pj, Pk, P1, IW#, OPCD, P1, Pj, Pk, I/P1, Cj, Ck, Cl, ROB#, PC, R1, oP1, s, x, c. Includes instructions like LW R2,0(R1), MUL R4,R2,R2, SW R4,0(R1), etc.

PHYSICAL REGS: 1 2 3 4 5 6 7 8
qi: 1 0 1 1 1 0 0 0
vi: 00 04 00 04 00 00 00 00

REG.FILE: Ri: 1 2 3 4 5 6 7 8
Pi: 2 8 0 1 0 0 0 0
Qi: 0 0 0 0 0 0 0 0
Vi: 00001004 00000000 00003000 00000000 00000000 00000000 00000003 00000000

Table with 10 columns: STAGES, TOTAL SLOTS, BUSY SLOTS, STALLS, F, D, P, I, X, W, C, RENAMED-STR, INSTRUCTION-WINDOW, REORDER-BUFFER, A, M, L, S, B, F, X

PC INSTRUCTION table with columns: PC, INSTRUCTION, F, D, P, I, X, W, C, P1, Pj, Pk, P1, IW#, OPCD, P1, Pj, Pk, I/P1, Cj, Ck, Cl, ROB#, PC, R1, oP1, s, x, c. Includes instructions like LW R2,0(R1), MUL R4,R2,R2, SW R4,0(R1), etc.

PHYSICAL REGS: 1 2 3 4 5 6 7 8
qi: 1 0 1 1 1 0 0 0
vi: 00 04 00 04 00 00 00 00

REG.FILE: Ri: 1 2 3 4 5 6 7 8
Pi: 2 8 0 1 0 0 0 0
Qi: 0 0 0 0 0 0 0 0
Vi: 00001004 00000000 00003000 00000000 00000000 00000000 00000003 00000000

Table with 10 columns: STAGES, TOTAL SLOTS, BUSY SLOTS, STALLS, F, D, P, I, X, W, C, RENAMED-STR, INSTRUCTION-WINDOW, REORDER-BUFFER, A, M, L, S, B, F, X

PC INSTRUCTION table with columns: PC, INSTRUCTION, F, D, P, I, X, W, C, P1, Pj, Pk, P1, IW#, OPCD, P1, Pj, Pk, I/P1, Cj, Ck, Cl, ROB#, PC, R1, oP1, s, x, c. Includes instructions like LW R2,0(R1), MUL R4,R2,R2, SW R4,0(R1), etc.

Oct 22, 2024 7:50

run181031.txt

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| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|------|------|----------|---|----|----|----|----|----|----|------------|------|------|----|----|----|----|----|----|------|-----|-----|----|----|---|---|------|------|----|------|------|----|
| 010] | LW | R2,0(R1) | 4 | 5 | 7 | 8 | 9 | 11 | 15 | P8,0(P7) | ---- | LW | P8 | P7 | - | 0 | 7 | - | ---- | 000 | R2 | P5 | 0 | 0 | 1 | ---- | SW | P3 | 1000 | 11 | |
| 011] | MUL | R4,R2,R2 | 4 | 12 | 13 | 14 | 14 | | | P1,P8,P8 | ---- | MUL | P1 | P8 | P8 | - | 13 | 13 | - | 001 | 001 | R4 | P6 | 0 | 0 | 0 | ---- | SW | P6 | 1004 | 13 |
| 012] | SW | R4,0(R1) | 4 | 12 | 13 | 14 | 15 | | | ,0(P7)<-P1 | ---- | SW | - | P1 | P7 | 0 | - | 13 | - | 002 | 002 | - | - | 1 | 0 | 0 | ---- | SW | P1 | 1000 | 11 |
| 013] | ADDI | R1,R1,4 | 4 | 13 | 14 | 15 | 15 | 16 | | P2,P7,4 | ---- | ADDI | P2 | P7 | - | 4 | 14 | - | ---- | 003 | 003 | R1 | P7 | 0 | 0 | 0 | ---- | | | | |
| 014] | BNE | R2,R0,-5 | 5 | 13 | 14 | 15 | 15 | 16 | | ,P8,P0,-5 | ---- | BNE | - | P8 | P0 | -5 | - | 14 | - | 004 | 004 | - | - | 0 | 0 | 1 | ---- | | | | |

Press ENTER to continue (PC=6,IC=15,CK=18,CTOT=19,IPC=0.79)...

@018 stall due to NO SLOTS when trying to move instnction BNE/014 from stage W to stage C.

PHYSICAL REGS: 1 2 3 4 5 6 7 8

qi: 0 0 1 1 1 0 0 0

vi: 00 04 00 04 00 00 00 00

REG.FILE: Ri: 1 2 3 4 5 6 7 8

Pi: 2 8 - - 1 - - -

Qi: 0 0 0 0 0 0 0 0

Vi: 00001004 00000000 00003000 00000000 00000000 00000000 00000003 00000000

| | | | | | | | | | | | | | | | | | |
|--------------|---|---|---|---|----|---|----|-------------|--------------------|----------------|---|---|---|---|---|---|---|
| STAGES: | F | D | P | I | X | W | C | RENAMED-STR | INSTRUCTION-WINDOW | REORDER-BUFFER | A | M | L | S | B | F | X |
| TOTAL SLOTS: | 4 | 4 | 8 | 4 | 12 | 4 | 4 | 8 | 8 | 10 | 4 | 1 | 1 | 0 | 1 | 4 | 1 |
| BUSY SLOTS: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 5 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STALLS: | 0 | 8 | 1 | 8 | 0 | 0 | 10 | 8 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|------|-------------|----------|---|----|----|----|----|----|-----------|------------|------|------|------|----|----|----|------|----|------|------|------|-----|----|-----|---|------|-------|------|-----|------|------|------|----|
| PC | INSTRUCTION | F | D | P | I | X | W | C | P1,Pj | Pk | P1 | IW# | OPCD | Pi | Pj | Pk | I/P1 | Cj | Ck | Cl | ROB# | PC | Ri | oPi | s | x | c | | | | | | |
| 000] | LW | R2,0(R1) | 0 | 1 | 2 | 3 | 4 | 6 | 7 | P2,0(P1) | ---- | LW | P2 | P1 | - | 0 | 2 | - | ---- | 000 | R2 | - | 0 | 0 | 1 | ---- | LQ(0) | | | | | | |
| 001] | MUL | R4,R2,R2 | 0 | 1 | 2 | 6 | 6 | 11 | 12 | P3,P2,P2 | ---- | MUL | P3 | P2 | P2 | - | 6 | 6 | - | ---- | 001 | R4 | - | 0 | 0 | 1 | ---- | PC | OP | Pi | EFAD | Ci | |
| 002] | SW | R4,0(R1) | 0 | 1 | 2 | 4 | 5 | 11 | 12 | ,0(P1)<-P3 | ---- | SW | - | P3 | P1 | 0 | - | 2 | - | ---- | 002 | - | - | 1 | 0 | 1 | ---- | --- | LW | P2 | 1000 | 6 | |
| 003] | ADDI | R1,R1,4 | 0 | 1 | 2 | 3 | 3 | 4 | 12 | P4,P1,4 | ---- | ADDI | P4 | P1 | - | 4 | 2 | - | ---- | 003 | R1 | P1 | 0 | 0 | 1 | ---- | --- | LW | P5 | 1004 | 8 | | |
| 004] | BNE | R2,R0,-5 | 1 | 2 | 3 | 4 | 4 | 5 | 12 | ,P2,P0,-5 | ---- | BNE | - | P2 | P0 | -5 | - | 3 | - | ---- | 004 | - | - | 0 | 0 | 1 | ---- | --- | LW | P8 | 1008 | 11 | |
| 005] | LW | R2,0(R1) | 2 | 3 | 4 | 5 | 6 | 8 | 13 | P5,0(P4) | ---- | LW | P5 | P4 | - | 0 | 4 | - | ---- | 000 | R2 | P2 | 0 | 0 | 1 | ---- | | | | | | | |
| 006] | MUL | R4,R2,R2 | 2 | 3 | 4 | 8 | 8 | 13 | 14 | P6,P5,P5 | ---- | MUL | P6 | P5 | P5 | - | 8 | 8 | - | ---- | 001 | R4 | P3 | 0 | 0 | 1 | ---- | | | | | | |
| 007] | SW | R4,0(R1) | 2 | 3 | 4 | 6 | 7 | 13 | 14 | ,0(P4)<-P6 | ---- | SW | - | P6 | P4 | 0 | - | 4 | - | ---- | 002 | - | - | 1 | 0 | 1 | ---- | | | | | | |
| 008] | ADDI | R1,R1,4 | 2 | 3 | 4 | 5 | 5 | 6 | 14 | P7,P4,4 | ---- | ADDI | P7 | P4 | - | 4 | 4 | - | ---- | 003 | R1 | P4 | 0 | 0 | 1 | ---- | SQ(0) | | | | | | |
| 009] | BNE | R2,R0,-5 | 3 | 4 | 5 | 6 | 7 | 14 | ,P5,P0,-5 | ---- | BNE | - | P5 | P0 | -5 | - | 5 | - | ---- | 004 | - | - | 0 | 0 | 1 | ---- | PC | OP | P1 | EFAD | C1 | | |
| 010] | LW | R2,0(R1) | 4 | 5 | 7 | 8 | 9 | 11 | 15 | P8,0(P7) | ---- | LW | P8 | P7 | - | 0 | 7 | - | ---- | 000 | R2 | P5 | 0 | 0 | 1 | ---- | --- | SW | P3 | 1000 | 11 | | |
| 011] | MUL | R4,R2,R2 | 4 | 12 | 13 | 14 | 14 | 19 | | P1,P8,P8 | ---- | MUL | P1 | P8 | P8 | - | 13 | 13 | - | ---- | 001 | 001 | R4 | P6 | 0 | 0 | 1 | ---- | --- | SW | P6 | 1004 | 13 |
| 012] | SW | R4,0(R1) | 4 | 12 | 13 | 14 | 15 | 19 | | ,0(P7)<-P1 | ---- | SW | - | P1 | P7 | 0 | - | 13 | - | ---- | 002 | 002 | - | - | 1 | 0 | 1 | ---- | --- | SW | P1 | 1000 | 19 |
| 013] | ADDI | R1,R1,4 | 4 | 13 | 14 | 15 | 15 | 16 | | P2,P7,4 | ---- | ADDI | P2 | P7 | - | 4 | 14 | - | ---- | 003 | 003 | R1 | P7 | 0 | 0 | 1 | ---- | | | | | | |
| 014] | BNE | R2,R0,-5 | 5 | 13 | 14 | 15 | 15 | 16 | | ,P8,P0,-5 | ---- | BNE | - | P8 | P0 | -5 | - | 14 | - | ---- | 004 | 004 | - | - | 0 | 0 | 1 | ---- | | | | | |

Press ENTER to continue (PC=6,IC=15,CK=19,CTOT=20,IPC=0.75)...

@019 stall due to NO SLOTS when trying to move instnction BNE/014 from stage W to stage C.

PHYSICAL REGS: 1 2 3 4 5 6 7 8

qi: 0 0 1 1 1 1 0 0

vi: 00 04 00 04 00 00 00 00

REG.FILE: Ri: 1 2 3 4 5 6 7 8

Pi: 2 8 - - 1 - - -

Qi: 0 0 0 0 0 0 0 0

Vi: 00001000 00000000 00003000 00000000 00000000 00000000 00000003 00000000

| | | | | | | | | | | | | | | | | | |
|--------------|---|---|---|---|----|---|----|-------------|--------------------|----------------|---|---|---|---|---|---|---|
| STAGES: | F | D | P | I | X | W | C | RENAMED-STR | INSTRUCTION-WINDOW | REORDER-BUFFER | A | M | L | S | B | F | X |
| TOTAL SLOTS: | 4 | 4 | 8 | 4 | 12 | 4 | 4 | 8 | 8 | 10 | 4 | 1 | 1 | 0 | 1 | 4 | 1 |
| BUSY SLOTS: | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STALLS: | 0 | 8 | 1 | 8 | 0 | 0 | 10 | 8 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|------|-------------|----------|---|----|----|----|----|----|-----------|------------|------|------|------|----|----|----|------|----|------|------|------|-----|----|-----|---|------|-------|------|-----|------|------|------|----|
| PC | INSTRUCTION | F | D | P | I | X | W | C | P1,Pj | Pk | P1 | IW# | OPCD | Pi | Pj | Pk | I/P1 | Cj | Ck | Cl | ROB# | PC | Ri | oPi | s | x | c | | | | | | |
| 000] | LW | R2,0(R1) | 0 | 1 | 2 | 3 | 4 | 6 | 7 | P2,0(P1) | ---- | LW | P2 | P1 | - | 0 | 2 | - | ---- | 000 | R2 | - | 0 | 0 | 1 | ---- | LQ(0) | | | | | | |
| 001] | MUL | R4,R2,R2 | 0 | 1 | 2 | 6 | 6 | 11 | 12 | P3,P2,P2 | ---- | MUL | P3 | P2 | P2 | - | 6 | 6 | - | ---- | 001 | R4 | - | 0 | 0 | 1 | ---- | PC | OP | Pi | EFAD | Ci | |
| 002] | SW | R4,0(R1) | 0 | 1 | 2 | 4 | 5 | 11 | 12 | ,0(P1)<-P3 | ---- | SW | - | P3 | P1 | 0 | - | 2 | - | ---- | 002 | - | - | 1 | 0 | 1 | ---- | --- | LW | P2 | 1000 | 6 | |
| 003] | ADDI | R1,R1,4 | 0 | 1 | 2 | 3 | 3 | 4 | 12 | P4,P1,4 | ---- | ADDI | P4 | P1 | - | 4 | 2 | - | ---- | 003 | R1 | P1 | 0 | 0 | 1 | ---- | --- | LW | P5 | 1004 | 8 | | |
| 004] | BNE | R2,R0,-5 | 1 | 2 | 3 | 4 | 4 | 5 | 12 | ,P2,P0,-5 | ---- | BNE | - | P2 | P0 | -5 | - | 3 | - | ---- | 004 | - | - | 0 | 0 | 1 | ---- | --- | LW | P8 | 1008 | 11 | |
| 005] | LW | R2,0(R1) | 2 | 3 | 4 | 5 | 6 | 8 | 13 | P5,0(P4) | ---- | LW | P5 | P4 | - | 0 | 4 | - | ---- | 000 | R2 | P2 | 0 | 0 | 1 | ---- | | | | | | | |
| 006] | MUL | R4,R2,R2 | 2 | 3 | 4 | 8 | 8 | 13 | 14 | P6,P5,P5 | ---- | MUL | P6 | P5 | P5 | - | 8 | 8 | - | ---- | 001 | R4 | P3 | 0 | 0 | 1 | ---- | | | | | | |
| 007] | SW | R4,0(R1) | 2 | 3 | 4 | 6 | 7 | 13 | 14 | ,0(P4)<-P6 | ---- | SW | - | P6 | P4 | 0 | - | 4 | - | ---- | 002 | - | - | 1 | 0 | 1 | ---- | | | | | | |
| 008] | ADDI | R1,R1,4 | 2 | 3 | 4 | 5 | 5 | 6 | 14 | P7,P4,4 | ---- | ADDI | P7 | P4 | - | 4 | 4 | - | ---- | 003 | R1 | P4 | 0 | 0 | 1 | ---- | SQ(0) | | | | | | |
| 009] | BNE | R2,R0,-5 | 3 | 4 | 5 | 6 | 7 | 14 | ,P5,P0,-5 | ---- | BNE | - | P5 | P0 | -5 | - | 5 | - | ---- | 004 | - | - | 0 | 0 | 1 | ---- | PC | OP | P1 | EFAD | C1 | | |
| 010] | LW | R2,0(R1) | 4 | 5 | 7 | 8 | 9 | 11 | 15 | P8,0(P7) | ---- | LW | P8 | P7 | - | 0 | 7 | - | ---- | 000 | R2 | P5 | 0 | 0 | 1 | ---- | --- | SW | P3 | 1000 | 11 | | |
| 011] | MUL | R4,R2,R2 | 4 | 12 | 13 | 14 | 14 | 19 | | P1,P8,P8 | ---- | MUL | P1 | P8 | P8 | - | 13 | 13 | - | ---- | 001 | 001 | R4 | P6 | 0 | 0 | 1 | ---- | --- | SW | P6 | 1004 | 13 |
| 012] | SW | R4,0(R1) | 4 | 12 | 13 | 14 | 15 | 19 | | ,0(P7)<-P1 | ---- | SW | - | P1 | P7 | 0 | - | 13 | - | ---- | 002 | 002 | - | - | 1 | 0 | 1 | ---- | --- | SW | P1 | 1000 | 19 |
| 013] | ADDI | R1,R1,4 | 4 | 13 | 14 | 15 | 15 | 16 | | P2,P7,4 | ---- | ADDI | P2 | P7 | - | 4 | 14 | - | ---- | 003 | 003 | R1 | P7 | 0 | 0 | 1 | ---- | | | | | | |
| 014] | BNE | R2,R0,-5 | 5 | 13 | 14 | 15 | 15 | 16 | | ,P8,P0,-5 | ---- | BNE | - | P8 | P0 | -5 | - | 14 | - | ---- | 004 | 004 | - | - | 0 | 0 | 1 | ---- | | | | | |

Press ENTER to continue (PC=6,IC=15,CK=20,CTOT=21,IPC=0.71)...

Program 'prog181031' FINISHED

PC=6,IC=15,CK=21,IPC=0.71
Goodbye.