

out150622.txt

Fri Oct 26 16:13:17 2018

1

./run150622.sh

TEST DATE: 150622

LIST OF INITIALIZATION PARAMETERS

-----[General]

Program Name = prog150622
Silent = no
Interactive = no
Batch File = yes

-----[Architecture]

Logical Registers = 8
Physical Registers = 12
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 = 99
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: 'prog150622'

000) 35 2 1 0 --> LW R2,0(R1)
001) 8 2 2 1 --> ADDI R2,R2,1
002) 24 4 2 2 --> MUL R4,R2,R2
003) 43 4 1 0 --> SW R4,0(R1)
004) 8 1 1 4 --> ADDI R1,R1,4
005) 5 2 0 -6 --> BNE R2,R0,-6

* TOTAL_INSTRUCTIONS=6

* 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)
        ADDI R2,R2,1
        MUL  R4,R2,R2
        SW   R4,0(R1)
        ADDI R1,R1,4
```

out150622.txt

Fri Oct 26 16:13:17 2018

2

BNE R2,R0,lab1

Working hypothesis:

- * the fetch, decode and commit stages are 4 instructions wide
- * the instruction window has 8 slots
- * we have 12 physical registers in the free pool
- * the reorder buffer has unlimited size
- * 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 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

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  9 10 11 12

               qi:  1  1  1  1  1  1  1  1  1  1  1  1
               vi:  00 00 00 00 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 12          8          99          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#  OPCODE Pi  Pj  Pk I/Pl  Cj Ck Cl  ROB# PC  Ri  oPi x s c  +-----+
000] LW   R2,0(R1)   0                                P2,0(P1)  8  99  4  1  1  0  1  4  1
001] ADDI R2,R2,1    0                                P3,P2,1  0  0  0  0  0  0  0  0
002] MUL  R4,R2,R2    0                                P4,P3,P3  0  0  0  0  0  0  0  0
003] SW   R4,0(R1)   0                                ,P0(P1)<-P4  0  0  0  0  0  0  0  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  9 10 11 12
               *  *  *  *
               qi:  0  1  1  1  1  1  1  1  1  1  1  1
               vi:  00 00 00 00 00 00 00 00 00 00 00 00
=====
REG.FILE: Ri:      1      2      3      4      5      6      7      8
           Pi:      1      3      -      4      -      -      -      -
           Qi:      0      1      0      1      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 12          8          99          4  1  1  0  1  4  1
BUSY SLOTS:        2  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 Pi,Pj Pk Pl  IW#  OPCODE Pi  Pj  Pk I/Pl  Cj Ck Cl  ROB# PC  Ri  oPi x s c  +-----+
000] LW   R2,0(R1)   0  1                                P2,0(P1)  8  99  4  1  1  0  1  4  1
001] ADDI R2,R2,1    0  1                                P3,P2,1  0  0  0  0  0  0  0  0
002] MUL  R4,R2,R2    0  1                                P4,P3,P3  0  0  0  0  0  0  0  0
003] SW   R4,0(R1)   0  1                                ,P0(P1)<-P4  0  0  0  0  0  0  0  0
004] ADDI R1,R1,4     1                                1  0  0  0  0  0  0  0
005] BNE  R2,R0,-6    1                                1  0  0  0  0  0  0  0
=====
----- Press ENTER to continue (PC=0,IC=6,CK=1,CTOT=2,IPC=3.00)...
=====
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12
               *  *  *  *  *
```

out150622.txt

Fri Oct 26 16:13:17 2018

3

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

=====
REG.FILE: Ri: 1 2 3 4 5 6 7 8
          Pi: 5 3 - 4 - - -
          Qi: 1 1 0 1 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 12 8 99 4 1 1 0 1 4 1
BUSY SLOTS: 4 2 4 0 0 0 0 5 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 Pi,Pj Pk P1 IW# OPCODE Pi Pj Pk I/P1 Cj Ck C1 ROB# PC Ri oPi x s c +-----+
000] LW R2,0(R1) 0 1 2 P2,0(P1) 000) LW P2 P1 - 0 2 - - 000) 000 R2 - 0 0 0 |LQ(0 )|
001] ADDI R2,R2,1 0 1 2 P3,P2,1 001) ADDI P3 P2 - 1 . - - 001) 001 R2 P2 0 0 0 |PC OP Pi EFAD Ci|
002] MUL R4,R2,R2 0 1 2 P4,P3,P3 002) MUL P4 P3 P3 - . . - 002) 002 R4 - 0 0 0 +-----+
003] SW R4,0(R1) 0 1 2 ,P0(P1)<--P4 003) SW - P4 P1 0 - 2 - 003) 003 - - 1 0 0
004] ADDI R1,R1,4 1 2 P5,P1,4
005] BNE R2,R0,-6 1 2 ,P3,P0,-6
006] LW R2,0(R1) 2
007] ADDI R2,R2,1 2
008] MUL R4,R2,R2 2
009] SW R4,0(R1) 2

=====
Press ENTER to continue (PC=4,IC=10,CK=2,CTOT=3,IPC=3.33)...
```

```
=====
PHYSICAL REGS: 1 2 3 4 5 6 7 8 9 10 11 12
               * * * * *
qi: 0 1 1 1 1 1 1 1 1 1 1 1
vi: 00 00 00 00 00 00 00 00 00 00 00 00

=====
REG.FILE: Ri: 1 2 3 4 5 6 7 8
          Pi: 5 7 - 8 - - -
          Qi: 1 1 0 1 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 12 8 99 4 1 1 0 1 4 1
BUSY SLOTS: 2 4 5 1 0 0 0 8 5 6 0 0 0 0 0 0 0
STALLS: 0 0 0 3 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 P1 IW# OPCODE Pi Pj Pk I/P1 Cj Ck C1 ROB# PC Ri oPi x s c +-----+
000] LW R2,0(R1) 0 1 2 3 P2,0(P1) 000> LW P2 P1 - 0 2 - - 000) 000 R2 - 0 0 0 |LQ(1 )|
001] ADDI R2,R2,1 0 1 2 P3,P2,1 001) ADDI P3 P2 - 1 . - - 001) 001 R2 P2 0 0 0 |PC OP Pi EFAD Ci|
002] MUL R4,R2,R2 0 1 2 P4,P3,P3 002) MUL P4 P3 P3 - . . - 002) 002 R4 - 0 0 0 |000] LW P2 0000 .|
003] SW R4,0(R1) 0 1 2 ,P0(P1)<--P4 003) SW - P4 P1 0 - 2 - 003) 003 - - 1 0 0 +-----+
004] ADDI R1,R1,4 1 2 3 P5,P1,4 000) ADDI P5 P1 - 4 3 - - 004) 004 R1 P1 0 0 0
005] BNE R2,R0,-6 1 2 3 ,P3,P0,-6 004) BNE - P3 P0 -6 - 3 - 005) 005 - - 0 0 0
006] LW R2,0(R1) 2 3 P6,0(P5)
007] ADDI R2,R2,1 2 3 P7,P6,1
008] MUL R4,R2,R2 2 3 P8,P7,P7
009] SW R4,0(R1) 2 3 ,P0(P5)<--P8
010] ADDI R1,R1,4 3
011] BNE R2,R0,-6 3

=====
Press ENTER to continue (PC=0,IC=12,CK=3,CTOT=4,IPC=3.00)...

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

```
=====
PHYSICAL REGS: 1 2 3 4 5 6 7 8 9 10 11 12
               * * * * *
qi: 0 1 1 1 1 1 1 1 1 1 1 1
vi: 00 00 00 00 04 00 00 00 00 00 00 00

=====
REG.FILE: Ri: 1 2 3 4 5 6 7 8
          Pi: 9 7 - 8 - - -
```

out150622.txt

Fri Oct 26 16:13:17 2018

4

```

      Qi:      1      1      0      1      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 12      8      99      4 1 1 0 1 4 1
BUSY SLOTS:   4 2 6 1 3 0 0 9      6      10      0 0 0 0 0 0 0
STALLS:       0 0 0 5 0 0 0 0      0      0      0 0 0 1 0 0 0
=====
PC  INSTRUCTION      F D P I X W C Pi,Pj Pk P1  IW#  OPCODE Pi Pj Pk I/P1  Cj Ck Cl  ROB# PC Ri  oPi x s 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  |LQ(1 ) |
001] ADDI R2,R2,1     0 1 2      P3,P2,1  001) ADDI P3 P2 - 1 . - - 001) 001 R2 P2 0 0 0  |PC  OP Pi EFAD Ci|
002] MUL  R4,R2,R2    0 1 2      P4,P3,P3  002) MUL P4 P3 P3 - . . - 002) 002 R4 - 0 0 0  |000] LW P2 1000 .|
003] SW  R4,0(R1)     0 1 2 4      ,P0(P1)<-P4 003> SW - P4 P1 0 - 2 - 003) 003 - - 1 0 0  +-----+
004] ADDI R1,R1,4     1 2 3 4 4      P5,P1,4  000> ADDI P5 P1 - 4 3 - - 004) 004 R1 P1 0 0 0
005] BNE  R2,R0,-6    1 2 3 4 4      ,P3,P0,-6 004> BNE - P3 P0 -6 - 3 - 005) 005 - - 0 0 0  +-----+
006] LW  R2,0(R1)     2 3 4      P6,0(P5)  000) LW P6 P5 - 0 . - - 006) 000 R2 P3 0 0 0  |SQ(1 ) |
007] ADDI R2,R2,1     2 3 4      P7,P6,1  003) ADDI P7 P6 - 1 . - - 007) 001 R2 P6 0 0 0  |PC  OP Pi EFAD Cl|
008] MUL  R4,R2,R2    2 3 4      P8,P7,P7  004) MUL P8 P7 P7 - . . - 008) 002 R4 P4 0 0 0  |003] SW P0 0000 .|
009] SW  R4,0(R1)     2 3 4      ,P0(P5)<-P8 005) SW - P8 P5 0 - . - 009) 003 - - 1 0 0  +-----+
010] ADDI R1,R1,4     3 4      P9,P5,4
011] BNE  R2,R0,-6    3 4      ,P7,P0,-6
012] LW  R2,0(R1)     4
013] ADDI R2,R2,1     4
014] MUL  R4,R2,R2    4
015] SW  R4,0(R1)     4
=====
```

Press ENTER to continue (PC=4,IC=16,CK=4,CTOT=5,IPC=3.20)...

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

@004 stall due to NO SLOTS when trying to move instnction MUL/002 from stage P to stage I.

```

=====
PHYSICAL REGS:  1 2 3 4 5 6 7 8 9 10 11 12
                * * * * *
      qi:  0 1 1 1 0 1 1 1 1 1 1 1
      vi:  00 00 00 00 04 00 00 00 00 00 00 00
=====
REG.FILE: Ri:      1      2      3      4      5      6      7      8
          P1:      9      11     -      12     -      -      -      -
          Qi:      1      1      0      1      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 12      8      99      4 1 1 0 1 4 1
BUSY SLOTS:   2 4 7 1 1 1 0 12      7      12      0 0 0 0 0 0 0
STALLS:       0 0 0 10 0 0 0 0      0      0      0 0 0 2 0 0 0
=====
PC  INSTRUCTION      F D P I X W C Pi,Pj Pk P1  IW#  OPCODE Pi Pj Pk I/P1  Cj Ck Cl  ROB# PC Ri  oPi x s 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  |LQ(2 ) |
001] ADDI R2,R2,1     0 1 2      P3,P2,1  001) ADDI P3 P2 - 1 . - - 001) 001 R2 P2 0 0 0  |PC  OP Pi EFAD Ci|
002] MUL  R4,R2,R2    0 1 2      P4,P3,P3  002) MUL P4 P3 P3 - . . - 002) 002 R4 - 0 0 0  |000] LW P2 1000 .|
003] SW  R4,0(R1)     0 1 2 4 5      ,P0(P1)<-P4 ----  SW - P4 P1 0 - 2 - 003) 003 - - 1 0 0  |006] LW P6 0000 5|
004] ADDI R1,R1,4     1 2 3 4 4 5      P5,P1,4  ----  ADDI P5 P1 - 4 3 - - 004) 004 R1 P1 0 0 1  +-----+
005] BNE  R2,R0,-6    1 2 3 4 4 5      ,P3,P0,-6 ----  BNE - P3 P0 -6 - 3 - 005) 005 - - 0 0 1
006] LW  R2,0(R1)     2 3 4 5      P6,0(P5)  000> LW P6 P5 - 0 5 - - 006) 000 R2 P3 0 0 0  +-----+
007] ADDI R2,R2,1     2 3 4      P7,P6,1  003) ADDI P7 P6 - 1 . - - 007) 001 R2 P6 0 0 0  |SQ(1 ) |
008] MUL  R4,R2,R2    2 3 4      P8,P7,P7  004) MUL P8 P7 P7 - . . - 008) 002 R4 P4 0 0 0  |PC  OP Pi EFAD Cl|
009] SW  R4,0(R1)     2 3 4      ,P0(P5)<-P8 005) SW - P8 P5 0 - 5 - 009) 003 - - 1 0 0  |003] SW P0 1000 .|
010] ADDI R1,R1,4     3 4 5      P9,P5,4  000) ADDI P9 P5 - 4 5 - - 010) 004 R1 P5 0 0 0  +-----+
011] BNE  R2,R0,-6    3 4 5      ,P7,P0,-6 006) BNE - P7 P0 -6 - 5 - 011) 005 - - 0 0 0
012] LW  R2,0(R1)     4 5      P10,0(P9)
013] ADDI R2,R2,1     4 5      P11,P10,1
014] MUL  R4,R2,R2    4 5      P12,P11,P11
015] SW  R4,0(R1)     4 5      ,P0(P9)<-P12
016] ADDI R1,R1,4     5
017] BNE  R2,R0,-6    5
=====
```

Press ENTER to continue (PC=7,IC=18,CK=5,CTOT=6,IPC=3.00)...

@005 stall due to NO SLOTS when trying to move instnction ADDI/001 from stage P to stage I.

@005 stall due to NO SLOTS when trying to move instnction MUL/002 from stage P to stage I.

@005 stall due to NO SLOTS when trying to move instnction ADDI/007 from stage P to stage I.

@005 stall due to NO SLOTS when trying to move instnction MUL/008 from stage P to stage I.

@005 stall due to no S-unit available

out150622.txt

Fri Oct 26 16:13:17 2018

5

@005 stall due to NO SLOTS when trying to move instnction SW/009 from stage P to stage I.

```
=====
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12
                 *  *  *  *  *  *  *  *  *  *  *  *
qi:  0  0  1  1  0  1  1  1  1  1  1  1
vi:  00 00 01 00 04 00 00 00 08 00 00 00
=====
```

```
=====
REG.FILE: Ri:      1      2      3      4      5      6      7      8
Pi:      9      11      -      12      -      -      -      -
Qi:      1      1      0      1      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 12          8          99          4  1  1  0  1  4  1
BUSY SLOTS:       2  0  8  1  3  1  0 12          8          16          0  0  0  0  0  0  0
STALLS:          0  1  0 14  0  0  1 1          0          0          0  0  0  2  0  0  0
=====
```

```
=====
PC  INSTRUCTION      F  D  P  I  X  W  C  Pi,Pj Pk Pl  IW#  OPCODE Pi  Pj  Pk I/Pl  Cj  Ck  Cl  ROB#  PC  Ri  oPi  x  s  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  |LQ(1 )|
001] ADDI R2,R2,1     0  1  2  6  6      P3,P2,1    001> ADDI P3  P2  -  1  6  -  -  001) 001 R2  P2  0  0  0  |PC  OP Pi  EFAD Ci|
002] MUL  R4,R2,R2     0  1  2      P4,P3,P3    002)  MUL P4  P3  P3  -  .  -  -  002) 002 R4  -  0  0  0  |---- LW P2 1000 6|
003] SW   R4,0(R1)    0  1  2  4  5      ,P0(P1)<-P4  ----  SW  -  P4  P1  0  -  2  -  -  003) 003  -  -  1  0  0  |006] LW P6 1004 5|
004] ADDI R1,R1,4     1  2  3  4  4  5      P5,P1,4    ----  ADDI P5  P1  -  4  3  -  -  004) 004 R1  P1  0  0  1  +-----+
005] BNE  R2,R0,-6     1  2  3  4  4  5      ,P3,P0,-6  ----  BNE  -  P3  P0 -6  -  3  -  -  005) 005  -  -  0  0  1
006] LW   R2,0(R1)     2  3  4  5  6      P6,0(P5)    ----  LW  P6  P5  -  0  5  -  -  006) 000 R2  P3  0  0  0  +-----+
007] ADDI R2,R2,1     2  3  4      P7,P6,1    003) ADDI P7  P6  -  1  .  -  -  007) 001 R2  P6  0  0  0  |SQ(2 )|
008] MUL  R4,R2,R2     2  3  4      P8,P7,P7    004)  MUL P8  P7  P7  -  .  .  -  008) 002 R4  P4  0  0  0  |PC  OP Pi  EFAD Cl|
009] SW   R4,0(R1)    2  3  4  6      ,P0(P5)<-P8  005>  SW  -  P8  P5  0  -  5  -  -  009) 003  -  -  1  0  0  |003] SW P0 1000 .|
010] ADDI R1,R1,4     3  4  5  6  6      P9,P5,4    000> ADDI P9  P5  -  4  5  -  -  010) 004 R1  P5  0  0  0  |009] SW P0 0000 .|
011] BNE  R2,R0,-6     3  4  5      ,P7,P0,-6  006)  BNE  -  P7  P0 -6  -  5  -  -  011) 005  -  -  0  0  0  +-----+
012] LW   R2,0(R1)     4  5  6      P10,0(P9)  000)  LW  P10 P9  -  0  .  -  -  012) 000 R2  P7  0  0  0
013] ADDI R2,R2,1     4  5  6      P11,P10,1  001) ADDI P11 P10 -  1  .  -  -  013) 001 R2  P10 0  0  0
014] MUL  R4,R2,R2     4  5  6      P12,P11,P11 005)  MUL P12 P11 P11 -  .  .  -  014) 002 R4  P8  0  0  0
015] SW   R4,0(R1)    4  5  6      ,P0(P9)<-P12 007)  SW  -  P12 P9  0  -  .  -  015) 003  -  -  1  0  0
016] ADDI R1,R1,4     5
017] BNE  R2,R0,-6     5
=====
```

----- Press ENTER to continue (PC=7,IC=18,CK=6,CTOT=7,IPC=2.57)...

@006 stall due to NO SLOTS when trying to move instnction BNE/005 from stage W to stage C.
@006 stall due to NO SLOTS when trying to move instnction MUL/002 from stage P to stage I.
@006 stall due to NO SLOTS when trying to move instnction ADDI/007 from stage P to stage I.
@006 stall due to NO SLOTS when trying to move instnction MUL/008 from stage P to stage I.
@006 stall due to NO SLOTS when trying to move instnction BNE/011 from stage P to stage I.
@006 stall due to Physical registers not available
@006 stall due to NO SLOTS when trying to move instnction ADDI/016 from stage F to stage D.

```
=====
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12
                 *  *  *  *  *  *  *  *  *  *  *  *
qi:  0  0  0  1  0  0  1  1  1  0  1  1
vi:  00 00 01 01 04 00 00 00 08 00 00 00
=====
```

```
=====
REG.FILE: Ri:      1      2      3      4      5      6      7      8
Pi:      9      11      -      12      -      -      -      -
Qi:      0      1      0      1      0      0      0      0
Vi:  00001008 00000001 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 12          8          99          4  1  1  0  1  4  1
BUSY SLOTS:       2  0  5  1  3  1  0 12          5          15          0  0  0  0  0  0  0
STALLS:          0  2  0 19  0  0  1 2          0          0          0  0  0  2  0  0  0
=====
```

```
=====
PC  INSTRUCTION      F  D  P  I  X  W  C  Pi,Pj Pk Pl  IW#  OPCODE Pi  Pj  Pk I/Pl  Cj  Ck  Cl  ROB#  PC  Ri  oPi  x  s  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(2 )|
001] ADDI R2,R2,1     0  1  2  6  6  7      P3,P2,1    ----  ADDI P3  P2  -  1  6  -  -  001) 001 R2  P2  0  0  1  |PC  OP Pi  EFAD Ci|
002] MUL  R4,R2,R2     0  1  2  7  7      P4,P3,P3    002>  MUL P4  P3  P3  -  7  7  -  -  002) 002 R4  -  0  0  0  |---- LW P2 1000 6|
003] SW   R4,0(R1)    0  1  2  4  5      ,P0(P1)<-P4  ----  SW  -  P4  P1  0  -  2  -  -  003) 003  -  -  1  0  0  |006] LW P6 1004 5|
004] ADDI R1,R1,4     1  2  3  4  4  5      P5,P1,4    ----  ADDI P5  P1  -  4  3  -  -  004) 004 R1  P1  0  0  1  |012] LW P10 0000 7|
=====
```

out150622.txt

Fri Oct 26 16:13:17 2018

6

```
005] BNE R2,R0,-6      1 2 3 4 4 5      ,P3,P0,-6      ---- BNE - P3 P0 -6 - 3 - 005) 005 - - 0 0 1 +-----+
006] LW R2,0(R1)        2 3 4 5 6          P6,0(P5)      ---- LW P6 P5 - 0 5 - - 006) 000 R2 P3 0 0 0
007] ADDI R2,R2,1        2 3 4          P7,P6,1          003) ADDI P7 P6 - 1 . - - 007) 001 R2 P6 0 0 0 +-----+
008] MUL R4,R2,R2        2 3 4          P8,P7,P7          004) MUL P8 P7 P7 - . - - 008) 002 R4 P4 0 0 0 |SQ(2 )|
009] SW R4,0(R1)         2 3 4 6 7          ,P0(P5)<-P8    ---- SW - P8 P5 0 - 5 - - 009) 003 - - 1 0 0 |PC OP Pi EFAD C1|
010] ADDI R1,R1,4        3 4 5 6 6 7      P9,P5,4        ---- ADDI P9 P5 - 4 5 - - 010) 004 R1 P5 0 0 1 |003] SW P0 1000 .|
011] BNE R2,R0,-6       3 4 5 7 7          ,P7,P0,-6      006> BNE - P7 P0 -6 - 5 - - 011) 005 - - 0 0 0 |009] SW P0 1004 .|
012] LW R2,0(R1)         4 5 6 7          P10,0(P9)       000> LW P10 P9 - 0 7 - - 012) 000 R2 P7 0 0 0 +-----+
013] ADDI R2,R2,1        4 5 6          P11,P10,1         001) ADDI P11 P10 - 1 . - - 013) 001 R2 P10 0 0 0
014] MUL R4,R2,R2        4 5 6          P12,P11,P11        005) MUL P12 P11 P11 - . - - 014) 002 R4 P8 0 0 0
015] SW R4,0(R1)         4 5 6          ,P0(P9)<-P12       007) SW - P12 P9 0 - 7 - - 015) 003 - - 1 0 0
016] ADDI R1,R1,4        5
017] BNE R2,R0,-6       5
```

----- Press ENTER to continue (PC=7,IC=18,CK=7,CTOT=8,IPC=2.25)...

```
@007 stall due to NO SLOTS when trying to move instuction ADDI/007 from stage P to stage I.
@007 stall due to NO SLOTS when trying to move instuction MUL/008 from stage P to stage I.
@007 stall due to NO SLOTS when trying to move instuction ADDI/013 from stage P to stage I.
@007 stall due to NO SLOTS when trying to move instuction MUL/014 from stage P to stage I.
@007 stall due to NO SLOTS when trying to move instuction SW/015 from stage P to stage I.
@007 stall due to Physical registers not available
@007 stall due to NO SLOTS when trying to move instuction ADDI/016 from stage F to stage D.
```

```
=====
PHYSICAL REGS:  1 2 3 4 5 6 7 8 9 10 11 12
                * * * * *
qi:  0 1 0 1 0 0 1 1 0 1 1 1
vi:  00 00 01 01 04 00 01 00 08 00 00 00
=====
REG.FILE: Ri:      1      2      3      4      5      6      7      8
Pi:      2      11     -     12     -     -     -     -
Qi:      1      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 12          8          99          4 1 1 0 1 4 1
BUSY SLOTS:       0 2 3 1 3 1 0 12          3          14          0 0 0 0 0 0 0
STALLS:           0 2 0 22 0 0 1 2          0          0          0 0 0 2 0 0 0
=====
```

```
PC INSTRUCTION      F D P I X W C Pi,Pj Pk P1  IW#  OPCODE Pi Pj Pk I/P1  Cj Ck C1  ROB# PC Ri oPi x s c +-----+
000] LW R2,0(R1)      0 1 2 3 4 6 7 P2,P0(P1)  ---- LW P2 P1 - 0 2 - - ---- 000 R2 - 0 0 1 |LQ(1 )|
001] ADDI R2,R2,1      0 1 2 6 6 7 8 P3,P2,1  ---- ADDI P3 P2 - 1 6 - - ---- 001 R2 P2 0 0 1 |PC OP Pi EFAD Ci|
002] MUL R4,R2,R2      0 1 2 7 7          P4,P3,P3  ---- MUL P4 P3 P3 - 7 7 - - ---- 002) 002 R4 - 0 0 0 |---- LW P2 1000 6|
003] SW R4,0(R1)       0 1 2 4 5          ,P0(P1)<-P4  ---- SW - P4 P1 0 - 2 - - ---- 003) 003 - - 1 0 0 |---- LW P6 1004 8|
004] ADDI R1,R1,4       1 2 3 4 4 5          P5,P1,4  ---- ADDI P5 P1 - 4 3 - - ---- 004) 004 R1 P1 0 0 1 |012] LW P10 1008 7|
005] BNE R2,R0,-6      1 2 3 4 4 5          ,P3,P0,-6  ---- BNE - P3 P0 -6 - 3 - - ---- 005) 005 - - 0 0 1 +-----+
006] LW R2,0(R1)       2 3 4 5 6 8          P6,0(P5)  ---- LW P6 P5 - 0 5 - - ---- 006) 000 R2 P3 0 0 1
007] ADDI R2,R2,1       2 3 4 8 8          P7,P6,1          003> ADDI P7 P6 - 1 8 - - ---- 007) 001 R2 P6 0 0 0 +-----+
008] MUL R4,R2,R2       2 3 4          P8,P7,P7          004) MUL P8 P7 P7 - . - - ---- 008) 002 R4 P4 0 0 0 |SQ(3 )|
009] SW R4,0(R1)        2 3 4 6 7          ,P0(P5)<-P8    ---- SW - P8 P5 0 - 5 - - ---- 009) 003 - - 1 0 0 |PC OP Pi EFAD C1|
010] ADDI R1,R1,4       3 4 5 6 6 7      P9,P5,4        ---- ADDI P9 P5 - 4 5 - - ---- 010) 004 R1 P5 0 0 1 |003] SW P0 1000 .|
011] BNE R2,R0,-6      3 4 5 7 7 8          ,P7,P0,-6  ---- BNE - P7 P0 -6 - 5 - - ---- 011) 005 - - 0 0 1 |009] SW P0 1004 .|
012] LW R2,0(R1)       4 5 6 7 8          P10,0(P9)       ---- LW P10 P9 - 0 7 - - ---- 012) 000 R2 P7 0 0 0 |015] SW P0 0000 .|
013] ADDI R2,R2,1       4 5 6          P11,P10,1         001) ADDI P11 P10 - 1 . - - ---- 013) 001 R2 P10 0 0 0 +-----+
014] MUL R4,R2,R2       4 5 6          P12,P11,P11        005) MUL P12 P11 P11 - . - - ---- 014) 002 R4 P8 0 0 0
015] SW R4,0(R1)       4 5 6 8          ,P0(P9)<-P12       007> SW - P12 P9 0 - 7 - - ---- 015) 003 - - 1 0 0
016] ADDI R1,R1,4       5 8          P2,P9,4
017] BNE R2,R0,-6      5 8          ,P11,P0,-6
```

----- Press ENTER to continue (PC=7,IC=18,CK=8,CTOT=9,IPC=2.00)...

```
@008 stall due to NO SLOTS when trying to move instuction MUL/008 from stage P to stage I.
@008 stall due to NO SLOTS when trying to move instuction ADDI/013 from stage P to stage I.
@008 stall due to NO SLOTS when trying to move instuction MUL/014 from stage P to stage I.
```

```
=====
PHYSICAL REGS:  1 2 3 4 5 6 7 8 9 10 11 12
                * * * * *
qi:  0 1 0 1 0 1 0 0 1 0 1 1
vi:  00 00 01 01 04 00 01 01 08 00 00 00
=====
REG.FILE: Ri:      1      2      3      4      5      6      7      8
```

out150622.txt

Fri Oct 26 16:13:17 2018

7

```
Pi:      2      11      -      12      -      -      -
Qi:      1      1      0      1      0      0      0
Vi: 00001008 00000001 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 12      8      99      4 1 1 0 1 4 1
BUSY SLOTS:  0 0 4 0 3 1 0 12      4      16      0 0 0 0 0 0 0
STALLS:      0 2 0 24 0 0 2 2      0      0      0 0 0 2 0 0 0

=====
PC  INSTRUCTION      F D P I X W C Pi,Pj Pk P1      IW# OPCODE Pi Pj Pk I/P1 Cj Ck C1      ROB# PC Ri oPi x s 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] ADDI R2,R2,1      0 1 2 6 6 7 8 P3,P2,1      ---- ADDI P3 P2 - 1 6 - - ---- 001 R2 P2 0 0 1 |PC  OP Pi EFAD Ci|
002] MUL  R4,R2,R2      0 1 2 7 7      P4,P3,P3      ---- MUL P4 P3 P3 - 7 7 - 002) 002 R4 - 0 0 0 |---- LW P2 1000 6|
003] SW  R4,0(R1)      0 1 2 4 5      ,P0(P1)<--P4      ---- SW - P4 P1 0 - 2 - 003) 003 - - 1 0 0 |---- LW P6 1004 8|
004] ADDI R1,R1,4      1 2 3 4 4 5      P5,P1,4      ---- ADDI P5 P1 - 4 3 - - 004) 004 R1 P1 0 0 1 |012] LW P10 1008 7|
005] BNE  R2,R0,-6      1 2 3 4 4 5      ,P3,P0,-6      ---- BNE - P3 P0 -6 - 3 - 005) 005 - - 0 0 1 +-----+
006] LW  R2,0(R1)      2 3 4 5 6 8      P6,0(P5)      ---- LW P6 P5 - 0 5 - - 006) 000 R2 P3 0 0 1
007] ADDI R2,R2,1      2 3 4 8 8 9      P7,P6,1      ---- ADDI P7 P6 - 1 8 - - 007) 001 R2 P6 0 0 1 +-----+
008] MUL  R4,R2,R2      2 3 4 9 9      P8,P7,P7      004> MUL P8 P7 P7 - 9 9 - 008) 002 R4 P4 0 0 0 |SQ(3 )|
009] SW  R4,0(R1)      2 3 4 6 7      ,P0(P5)<--P8      ---- SW - P8 P5 0 - 5 - 009) 003 - - 1 0 0 |PC  OP Pi EFAD C1|
010] ADDI R1,R1,4      3 4 5 6 6 7      P9,P5,4      ---- ADDI P9 P5 - 4 5 - - 010) 004 R1 P5 0 0 1 |003] SW P0 1000 .|
011] BNE  R2,R0,-6      3 4 5 7 7 8      ,P7,P0,-6      ---- BNE - P7 P0 -6 - 5 - 011) 005 - - 0 0 1 |009] SW P0 1004 .|
012] LW  R2,0(R1)      4 5 6 7 8      P10,0(P9)      ---- LW P10 P9 - 0 7 - - 012) 000 R2 P7 0 0 0 |015] SW P0 1008 .|
013] ADDI R2,R2,1      4 5 6      P11,P10,1      001) ADDI P11 P10 - 1 . - 013) 001 R2 P10 0 0 0 +-----+
014] MUL  R4,R2,R2      4 5 6      P12,P11,P11      005) MUL P12 P11 P11 - . . - 014) 002 R4 P8 0 0 0
015] SW  R4,0(R1)      4 5 6 8 9      ,P0(P9)<--P12      ---- SW - P12 P9 0 - 7 - 015) 003 - - 1 0 0
016] ADDI R1,R1,4      5 8 9      P2,P9,4      000) ADDI P2 P9 - 4 9 - - 016) 004 R1 P9 0 0 0
017] BNE  R2,R0,-6      5 8 9      ,P11,P0,-6      002) BNE - P11 P0 -6 - 9 - 017) 005 - - 0 0 0

----- Press ENTER to continue (PC=7,IC=18,CK=9,CTOT=10,IPC=1.80)...
@009 stall due to NO SLOTS when trying to move instnction BNE/011 from stage W to stage C.
@009 stall due to NO SLOTS when trying to move instnction ADDI/013 from stage P to stage I.
@009 stall due to NO SLOTS when trying to move instnction MUL/014 from stage P to stage I.
```

```
=====
PHYSICAL REGS: 1 2 3 4 5 6 7 8 9 10 11 12
                * * * * *
qi: 0 1 0 1 0 0 0 1 0 0 1 1
vi: 00 0C 01 01 04 00 01 01 08 00 01 00

=====
REG.FILE: Ri:      1      2      3      4      5      6      7      8
Pi:      2      11      -      12      -      -      -      -
Qi:      1      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 12      8      99      4 1 1 0 1 4 1
BUSY SLOTS:  0 0 1 0 5 1 0 12      1      16      0 0 0 0 0 0 0
STALLS:      0 2 0 25 0 0 3 2      0      0      0 0 0 2 0 0 0

=====
PC  INSTRUCTION      F D P I X W C Pi,Pj Pk P1      IW# OPCODE Pi Pj Pk I/P1 Cj Ck C1      ROB# PC Ri oPi x s 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] ADDI R2,R2,1      0 1 2 6 6 7 8 P3,P2,1      ---- ADDI P3 P2 - 1 6 - - ---- 001 R2 P2 0 0 1 |PC  OP Pi EFAD Ci|
002] MUL  R4,R2,R2      0 1 2 7 7      P4,P3,P3      ---- MUL P4 P3 P3 - 7 7 - 002) 002 R4 - 0 0 0 |---- LW P2 1000 6|
003] SW  R4,0(R1)      0 1 2 4 5      ,P0(P1)<--P4      ---- SW - P4 P1 0 - 2 - 003) 003 - - 1 0 0 |---- LW P6 1004 8|
004] ADDI R1,R1,4      1 2 3 4 4 5      P5,P1,4      ---- ADDI P5 P1 - 4 3 - - 004) 004 R1 P1 0 0 1 |---- LW P10 1008 10|
005] BNE  R2,R0,-6      1 2 3 4 4 5      ,P3,P0,-6      ---- BNE - P3 P0 -6 - 3 - 005) 005 - - 0 0 1 +-----+
006] LW  R2,0(R1)      2 3 4 5 6 8      P6,0(P5)      ---- LW P6 P5 - 0 5 - - 006) 000 R2 P3 0 0 1
007] ADDI R2,R2,1      2 3 4 8 8 9      P7,P6,1      ---- ADDI P7 P6 - 1 8 - - 007) 001 R2 P6 0 0 1 +-----+
008] MUL  R4,R2,R2      2 3 4 9 9      P8,P7,P7      ---- MUL P8 P7 P7 - 9 9 - 008) 002 R4 P4 0 0 0 |SQ(3 )|
009] SW  R4,0(R1)      2 3 4 6 7      ,P0(P5)<--P8      ---- SW - P8 P5 0 - 5 - 009) 003 - - 1 0 0 |PC  OP Pi EFAD C1|
010] ADDI R1,R1,4      3 4 5 6 6 7      P9,P5,4      ---- ADDI P9 P5 - 4 5 - - 010) 004 R1 P5 0 0 1 |003] SW P0 1000 .|
011] BNE  R2,R0,-6      3 4 5 7 7 8      ,P7,P0,-6      ---- BNE - P7 P0 -6 - 5 - 011) 005 - - 0 0 1 |009] SW P0 1004 .|
012] LW  R2,0(R1)      4 5 6 7 8 10      P10,0(P9)      ---- LW P10 P9 - 0 7 - - 012) 000 R2 P7 0 0 1 |015] SW P0 1008 .|
013] ADDI R2,R2,1      4 5 6 10 10      P11,P10,1      001> ADDI P11 P10 - 1 10 - - 013) 001 R2 P10 0 0 0 +-----+
014] MUL  R4,R2,R2      4 5 6      P12,P11,P11      005) MUL P12 P11 P11 - . . - 014) 002 R4 P8 0 0 0
015] SW  R4,0(R1)      4 5 6 8 9      ,P0(P9)<--P12      ---- SW - P12 P9 0 - 7 - 015) 003 - - 1 0 0
016] ADDI R1,R1,4      5 8 9 10 10      P2,P9,4      000> ADDI P2 P9 - 4 9 - - 016) 004 R1 P9 0 0 0
017] BNE  R2,R0,-6      5 8 9 10 10      ,P11,P0,-6      002> BNE - P11 P0 -6 - 9 - 017) 005 - - 0 0 0

----- Press ENTER to continue (PC=7,IC=18,CK=10,CTOT=11,IPC=1.64)...
@010 stall due to NO SLOTS when trying to move instnction ADDI/007 from stage W to stage C.
```

out150622.txt

Fri Oct 26 16:13:17 2018

8

@010 stall due to NO SLOTS when trying to move instnction MUL/014 from stage P to stage I.

```
=====
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12
                 *  *  *  *  *  *  *  *  *  *  *  *
               qi:  0  0  0  1  0  0  0  1  0  0  0  1
               vi:  00 0C 01 01 04 00 01 01 08 00 01 01
=====
REG.FILE: Ri:      1      2      3      4      5      6      7      8
           Pi:      2      11     -      12     -      -      -      -
           Qi:      0      0      0      1      0      0      0      0
           Vi:  0000100C 00000001 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 12          8          99          4  1  1  0  1  4  1
BUSY SLOTS:       0  0  0  0  3  1  0 12          0          16          0  0  0  0  0  0  0
STALLS:           0  2  0 25  0  4  2          0          0          0  0  0  2  0  0  0
=====
PC  INSTRUCTION  F  D  P  I  X  W  C Pi,Pj Pk P1  IW#  OPCODE Pi  Pj  Pk I/P1  Cj  Ck  Cl  ROB#  PC  Ri  oPi x s 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] ADDI R2,R2,1  0  1  2  6  6  7  8 P3,P2,1  ----  ADDI P3 P2 -  1  6  -  -  ----  001 R2 P2  0  0  1  |PC  OP Pi  EFAD Ci|
002] MUL  R4,R2,R2  0  1  2  7  7  P4,P3,P3  ----  MUL P4 P3 P3 -  7  7  -  -  ----  002 R4 -  0  0  0  |----  LW P2 1000 6|
003] SW   R4,0(R1)  0  1  2  4  5  ,P0(P1)<--P4  ----  SW - P4 P1 0 -  2  -  -  ----  003) 003 -  -  1  0  0  |----  LW P6 1004 8|
004] ADDI R1,R1,4  1  2  3  4  4  5  P5,P1,4  ----  ADDI P5 P1 -  4  3  -  -  ----  004) 004 R1 P1 0  0  1  |----  LW P10 1008 10|
005] BNE  R2,R0,-6  1  2  3  4  4  5  ,P3,P0,-6  ----  BNE - P3 P0 -6 -  3  -  -  ----  005) 005 -  -  0  0  1  +-----+
006] LW   R2,0(R1)  2  3  4  5  6  8  P6,0(P5)  ----  LW P6 P5 -  0  5  -  -  ----  006) 000 R2 P3 0  0  1
007] ADDI R2,R2,1  2  3  4  8  8  9  P7,P6,1  ----  ADDI P7 P6 -  1  8  -  -  ----  007) 001 R2 P6 0  0  1  +-----+
008] MUL  R4,R2,R2  2  3  4  9  9  P8,P7,P7  ----  MUL P8 P7 P7 -  9  9  -  -  ----  008) 002 R4 P4 0  0  0  |SQ(3 )|
009] SW   R4,0(R1)  2  3  4  6  7  ,P0(P5)<--P8  ----  SW - P8 P5 0 -  5  -  -  ----  009) 003 -  -  1  0  0  |PC  OP Pi  EFAD Cl|
010] ADDI R1,R1,4  3  4  5  6  6  7  P9,P5,4  ----  ADDI P9 P5 -  4  5  -  -  ----  010) 004 R1 P5 0  0  1  |003] SW P0 1000 .|
011] BNE  R2,R0,-6  3  4  5  7  7  8  ,P7,P0,-6  ----  BNE - P7 P0 -6 -  5  -  -  ----  011) 005 -  -  0  0  1  |009] SW P0 1004 .|
012] LW   R2,0(R1)  4  5  6  7  8 10  P10,0(P9)  ----  LW P10 P9 -  0  7  -  -  ----  012) 000 R2 P7 0  0  1  |015] SW P0 1008 .|
013] ADDI R2,R2,1  4  5  6 10 10 11  P11,P10,1  ----  ADDI P11 P10 -  1 10  -  -  ----  013) 001 R2 P10 0  0  1  +-----+
014] MUL  R4,R2,R2  4  5  6 11 11  P12,P11,P11 005> MUL P12 P11 P11 - 11 11 -  -  ----  014) 002 R4 P8 0  0  0
015] SW   R4,0(R1)  4  5  6  8  9  ,P0(P9)<--P12  ----  SW - P12 P9 0 -  7  -  -  ----  015) 003 -  -  1  0  0
016] ADDI R1,R1,4  5  8  9 10 10 11  P2,P9,4  ----  ADDI P2 P9 -  4  9  -  -  ----  016) 004 R1 P9 0  0  1
017] BNE  R2,R0,-6  5  8  9 10 10 11  ,P11,P0,-6  ----  BNE - P11 P0 -6 -  9  -  -  ----  017) 005 -  -  0  0  1
=====
Press ENTER to continue (PC=7,IC=18,CK=11,CTOT=12,IPC=1.50)...
@011 stall due to NO SLOTS when trying to move instnction LW/012 from stage W to stage C.
```

```
=====
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12
                 *  *  *  *  *  *  *  *  *  *  *  *
               qi:  0  0  0  0  0  0  0  1  0  0  0  1
               vi:  00 0C 01 01 04 00 01 01 08 00 01 01
=====
REG.FILE: Ri:      1      2      3      4      5      6      7      8
           Pi:      2      11     -      12     -      -      -      -
           Qi:      0      0      0      1      0      0      0      0
           Vi:  0000100C 00000001 00003000 00000001 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 12          8          99          4  1  1  0  1  4  1
BUSY SLOTS:       0  0  0  0  2  1  0 12          0          16          0  0  0  0  0  0  0
STALLS:           0  2  0 25  0  5  2          0          0          0  0  0  2  0  0  0
=====
PC  INSTRUCTION  F  D  P  I  X  W  C Pi,Pj Pk P1  IW#  OPCODE Pi  Pj  Pk I/P1  Cj  Ck  Cl  ROB#  PC  Ri  oPi x s 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] ADDI R2,R2,1  0  1  2  6  6  7  8 P3,P2,1  ----  ADDI P3 P2 -  1  6  -  -  ----  001 R2 P2  0  0  1  |PC  OP Pi  EFAD Ci|
002] MUL  R4,R2,R2  0  1  2  7  7 12 P4,P3,P3  ----  MUL P4 P3 P3 -  7  7  -  -  ----  002) 002 R4 -  0  0  1  |----  LW P2 1000 6|
003] SW   R4,0(R1)  0  1  2  4  5 12 ,P0(P1)<--P4  ----  SW - P4 P1 0 -  2  -  -  ----  003) 003 -  -  1  0  1  |----  LW P6 1004 8|
004] ADDI R1,R1,4  1  2  3  4  4  5  P5,P1,4  ----  ADDI P5 P1 -  4  3  -  -  ----  004) 004 R1 P1 0  0  1  |----  LW P10 1008 10|
005] BNE  R2,R0,-6  1  2  3  4  4  5  ,P3,P0,-6  ----  BNE - P3 P0 -6 -  3  -  -  ----  005) 005 -  -  0  0  1  +-----+
006] LW   R2,0(R1)  2  3  4  5  6  8  P6,0(P5)  ----  LW P6 P5 -  0  5  -  -  ----  006) 000 R2 P3 0  0  1
007] ADDI R2,R2,1  2  3  4  8  8  9  P7,P6,1  ----  ADDI P7 P6 -  1  8  -  -  ----  007) 001 R2 P6 0  0  1  +-----+
008] MUL  R4,R2,R2  2  3  4  9  9  P8,P7,P7  ----  MUL P8 P7 P7 -  9  9  -  -  ----  008) 002 R4 P4 0  0  0  |SQ(2 )|
009] SW   R4,0(R1)  2  3  4  6  7  ,P0(P5)<--P8  ----  SW - P8 P5 0 -  5  -  -  ----  009) 003 -  -  1  0  0  |PC  OP Pi  EFAD Cl|
010] ADDI R1,R1,4  3  4  5  6  6  7  P9,P5,4  ----  ADDI P9 P5 -  4  5  -  -  ----  010) 004 R1 P5 0  0  1  |----  SW P0 1000 12|
011] BNE  R2,R0,-6  3  4  5  7  7  8  ,P7,P0,-6  ----  BNE - P7 P0 -6 -  5  -  -  ----  011) 005 -  -  0  0  1  |009] SW P0 1004 .|
012] LW   R2,0(R1)  4  5  6  7  8 10  P10,0(P9)  ----  LW P10 P9 -  0  7  -  -  ----  012) 000 R2 P7 0  0  1  |015] SW P0 1008 .|
=====
```


out150622.txt

Fri Oct 26 16:13:17 2018

9

```
013] ADDI R2,R2,1      4 5 6 10 10 11    P11,P10,1      ---- ADDI P11 P10 - 1 10 - - 013) 001 R2 P10 0 0 1 +-----+
014] MUL  R4,R2,R2      4 5 6 11 11      P12,P11,P11     ---- MUL P12 P11 P11 - 11 11 - 014) 002 R4 P8 0 0 0
015] SW   R4,0(R1)       4 5 6 8 9        ,P0(P9)<-P12     ---- SW - P12 P9 0 - 7 - 015) 003 - - 1 0 0
016] ADDI R1,R1,4       5 8 9 10 10 11    P2,P9,4        ---- ADDI P2 P9 - 4 9 - - 016) 004 R1 P9 0 0 1
017] BNE  R2,R0,-6      5 8 9 10 10 11    ,P11,P0,-6     ---- BNE - P11 P0 -6 - 9 - 017) 005 - - 0 0 1
```

----- Press ENTER to continue (PC=7,IC=18,CK=12,CTOT=13,IPC=1.38)...

@012 stall due to NO SLOTS when trying to move instruction BNE/017 from stage W to stage C.

```
=====
PHYSICAL REGS:  1 2 3 4 5 6 7 8 9 10 11 12
                  * * * * *
qi:  1 0 0 0 0 0 0 0 1 0 0 0 1
vi:  00 0C 01 01 04 00 01 01 08 00 01 01
```

```
=====
REG.FILE: Ri:      1      2      3      4      5      6      7      8
Pi:      2      11      -      12      -      -      -      -
Qi:      0          0          1          0          0          0
Vi:  00001000 00000001 00003000 00000001 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 12          8          99          4 1 1 0 1 4 1
BUSY SLOTS:      0 0 0 0 0 2 1 0 11         0          12          0 0 0 0 0 0 0
STALLS:          0 2 0 25 0 0 5 2           0          0          0 0 0 2 0 0 0
```

```
=====
PC  INSTRUCTION      F D P I X W C Pi,Pj Pk P1  IW#  OPCODE Pi Pj Pk I/P1 Cj Ck C1  ROB# PC Ri oPi x s 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] ADDI R2,R2,1     0 1 2 6 6 7 8 P3,P2,1  ---- ADDI P3 P2 - 1 6 - - ---- 001 R2 P2 0 0 1 |PC OP Pi EFAD Ci|
002] MUL  R4,R2,R2     0 1 2 7 7 12 13 P4,P3,P3  ---- MUL P4 P3 P3 - 7 7 - - ---- 002 R4 - 0 0 1 |---- LW P2 1000 6|
003] SW   R4,0(R1)     0 1 2 4 5 12 13 ,P0(P1)<-P4  ---- SW - P4 P1 0 - 2 - - ---- 003 - - 1 0 1 |---- LW P6 1004 8|
004] ADDI R1,R1,4     1 2 3 4 4 5 13 P5,P1,4  ---- ADDI P5 P1 - 4 3 - - ---- 004 R1 P1 0 0 1 |---- LW P10 1008 10|
005] BNE  R2,R0,-6    1 2 3 4 4 5 13 ,P3,P0,-6  ---- BNE - P3 P0 -6 - 3 - - ---- 005 - - 0 0 1 +-----+
006] LW  R2,0(R1)     2 3 4 5 6 8 P6,0(P5)  ---- LW P6 P5 - 0 5 - - ---- 006) 000 R2 P3 0 0 1
007] ADDI R2,R2,1     2 3 4 8 8 9 P7,P6,1  ---- ADDI P7 P6 - 1 8 - - ---- 007) 001 R2 P6 0 0 1 +-----+
008] MUL  R4,R2,R2     2 3 4 9 9 P8,P7,P7  ---- MUL P8 P7 P7 - 9 9 - - ---- 008) 002 R4 P4 0 0 0 |SQ(2 )|
009] SW   R4,0(R1)     2 3 4 6 7 P9,P5,4  ---- SW - P8 P5 0 - 5 - - ---- 009) 003 - - 1 0 0 |PC OP Pi EFAD Ci|
010] ADDI R1,R1,4     3 4 5 6 6 7 P9,P5,4  ---- ADDI P9 P5 - 4 5 - - ---- 010) 004 R1 P5 0 0 1 |---- SW P0 1000 12|
011] BNE  R2,R0,-6    3 4 5 7 7 8 P7,P0,-6  ---- BNE - P7 P0 -6 - 5 - - ---- 011) 005 - - 0 0 1 |009] SW P0 1004 .|
012] LW  R2,0(R1)     4 5 6 7 8 10 P10,0(P9)  ---- LW P10 P9 - 0 7 - - ---- 012) 000 R2 P7 0 0 1 |015] SW P0 1008 .|
013] ADDI R2,R2,1     4 5 6 10 10 11 P11,P10,1  ---- ADDI P11 P10 - 1 10 - - ---- 013) 001 R2 P10 0 0 1 +-----+
014] MUL  R4,R2,R2     4 5 6 11 11 P12,P11,P11  ---- MUL P12 P11 P11 - 11 11 - ---- 014) 002 R4 P8 0 0 0
015] SW   R4,0(R1)     4 5 6 8 9 P0(P9)<-P12  ---- SW - P12 P9 0 - 7 - - ---- 015) 003 - - 1 0 0
016] ADDI R1,R1,4     5 8 9 10 10 11 P2,P9,4  ---- ADDI P2 P9 - 4 9 - - ---- 016) 004 R1 P9 0 0 1
017] BNE  R2,R0,-6    5 8 9 10 10 11 ,P11,P0,-6  ---- BNE - P11 P0 -6 - 9 - - ---- 017) 005 - - 0 0 1
```

----- Press ENTER to continue (PC=7,IC=18,CK=13,CTOT=14,IPC=1.29)...

```
=====
PHYSICAL REGS:  1 2 3 4 5 6 7 8 9 10 11 12
                  * * * * *
qi:  1 0 1 0 0 0 1 0 0 0 0 0 1
vi:  00 0C 01 01 04 00 01 01 08 00 01 01
```

```
=====
REG.FILE: Ri:      1      2      3      4      5      6      7      8
Pi:      2      11      -      12      -      -      -      -
Qi:      0          0          1          0          0          0
Vi:  00001000 00000000 00003000 00000001 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 12          8          99          4 1 1 0 1 4 1
BUSY SLOTS:      0 0 0 0 1 1 0 9           0          10          0 0 0 0 0 0 0
STALLS:          0 2 0 25 0 0 5 2           0          0          0 0 0 2 0 0 0
```

```
=====
PC  INSTRUCTION      F D P I X W C Pi,Pj Pk P1  IW#  OPCODE Pi Pj Pk I/P1 Cj Ck C1  ROB# PC Ri oPi x s 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] ADDI R2,R2,1     0 1 2 6 6 7 8 P3,P2,1  ---- ADDI P3 P2 - 1 6 - - ---- 001 R2 P2 0 0 1 |PC OP Pi EFAD Ci|
002] MUL  R4,R2,R2     0 1 2 7 7 12 13 P4,P3,P3  ---- MUL P4 P3 P3 - 7 7 - - ---- 002 R4 - 0 0 1 |---- LW P2 1000 6|
003] SW   R4,0(R1)     0 1 2 4 5 12 13 ,P0(P1)<-P4  ---- SW - P4 P1 0 - 2 - - ---- 003 - - 1 0 1 |---- LW P6 1004 8|
004] ADDI R1,R1,4     1 2 3 4 4 5 13 P5,P1,4  ---- ADDI P5 P1 - 4 3 - - ---- 004 R1 P1 0 0 1 |---- LW P10 1008 10|
005] BNE  R2,R0,-6    1 2 3 4 4 5 13 ,P3,P0,-6  ---- BNE - P3 P0 -6 - 3 - - ---- 005 - - 0 0 1 +-----+
006] LW  R2,0(R1)     2 3 4 5 6 8 14 P6,0(P5)  ---- LW P6 P5 - 0 5 - - ---- 000 R2 P3 0 0 1
007] ADDI R2,R2,1     2 3 4 8 8 9 14 P7,P6,1  ---- ADDI P7 P6 - 1 8 - - ---- 001 R2 P6 0 0 1 +-----+
```

out150622.txt

Fri Oct 26 16:13:17 2018

10

```
008] MUL  R4,R2,R2      2  3  4  9  9 14      P8,P7,P7      ---- MUL P8 P7 P7 - 9 9 - 008) 002 R4 P4 0 0 1 |SQ(1 )|
009] SW   R4,0(R1)      2  3  4  6  7 14      ,P0(P5)<-P8      ---- SW - P8 P5 0 - 5 - 009) 003 - - 1 0 1 |PC OP Pi EFAD C1|
010] ADDI R1,R1,4       3  4  5  6  6  7      P9,P5,4       ---- ADDI P9 P5 - 4 5 - - 010) 004 R1 P5 0 0 1 |---- SW P0 1000 12|
011] BNE  R2,R0,-6      3  4  5  7  7  8      ,P7,P0,-6      ---- BNE - P7 P0 -6 - 5 - 011) 005 - - 0 0 1 |---- SW P0 1004 14|
012] LW   R2,0(R1)      4  5  6  7  8 10      P10,0(P9)      ---- LW P10 P9 - 0 7 - - 012) 000 R2 P7 0 0 1 |015] SW P0 1008 .|
013] ADDI R2,R2,1       4  5  6 10 10 11      P11,P10,1      ---- ADDI P11 P10 - 1 10 - - 013) 001 R2 P10 0 0 1 +-----+
014] MUL  R4,R2,R2      4  5  6 11 11      P12,P11,P11     ---- MUL P12 P11 P11 - 11 11 - 014) 002 R4 P8 0 0 0
015] SW   R4,0(R1)      4  5  6  8  9      ,P0(P9)<-P12     ---- SW - P12 P9 0 - 7 - 015) 003 - - 1 0 0
016] ADDI R1,R1,4       5  8  9 10 10 11      P2,P9,4       ---- ADDI P2 P9 - 4 9 - - 016) 004 R1 P9 0 0 1
017] BNE  R2,R0,-6      5  8  9 10 10 11      ,P11,P0,-6      ---- BNE - P11 P0 -6 - 9 - 017) 005 - - 0 0 1

----- Press ENTER to continue (PC=7,IC=18,CK=14,CTOT=15,IPC=1.20)...
```

```
=====
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12
                *                * * * * *
qi:  1  0  1  1  1  1  0  0  0  0  0  1
vi:  00 0C 01 01 04 00 01 01 08 00 01 01

=====
REG.FILE: Ri:      1      2      3      4      5      6      7      8
          Pi:      2      11     -      12     -      -      -      -
          Qi:      0      0      0      1      0      0      0      0
          Vi: 00001004 00000000 00003000 00000001 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 12          8                    99                    4 1 1 0 1 4 1
BUSY SLOTS:      0 0 0 0 1 1 0 7            0                    6                    0 0 0 0 0 0 0
STALLS:          0 2 0 25 0 0 5 2            0                    0                    0 0 0 2 0 0 0

=====
PC INSTRUCTION    F D P I X W C Pi,Pj Pk P1  IW#  OPCODE Pi Pj Pk I/P1  Cj Ck Cl  ROB# PC Ri oPi x s 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] ADDI R2,R2,1  0 1 2 6 6 7 8 P3,P2,1  ---- ADDI P3 P2 - 1 6 - - ---- 001 R2 P2 0 0 1 |PC OP Pi EFAD Ci|
002] MUL  R4,R2,R2  0 1 2 7 7 12 13 P4,P3,P3  ---- MUL P4 P3 P3 - 7 7 - - ---- 002 R4 - 0 0 1 |---- LW P2 1000 6|
003] SW   R4,0(R1)  0 1 2 4 5 12 13 ,P0(P1)<-P4  ---- SW - P4 P1 0 - 2 - - ---- 003 - - 1 0 1 |---- LW P6 1004 8|
004] ADDI R1,R1,4  1 2 3 4 4 5 13 P5,P1,4  ---- ADDI P5 P1 - 4 3 - - ---- 004 R1 P1 0 0 1 |---- LW P10 1008 10|
005] BNE  R2,R0,-6  1 2 3 4 4 5 13 ,P3,P0,-6  ---- BNE - P3 P0 -6 - 3 - - ---- 005 - - 0 0 1 +-----+
006] LW  R2,0(R1)  2 3 4 5 6 8 14 P6,0(P5)  ---- LW P6 P5 - 0 5 - - ---- 000 R2 P3 0 0 1
007] ADDI R2,R2,1  2 3 4 8 8 9 14 P7,P6,1  ---- ADDI P7 P6 - 1 8 - - ---- 001 R2 P6 0 0 1 +-----+
008] MUL  R4,R2,R2  2 3 4 9 9 14 15 P8,P7,P7  ---- MUL P8 P7 P7 - 9 9 - - ---- 002 R4 P4 0 0 1 |SQ(1 )|
009] SW   R4,0(R1)  2 3 4 6 7 14 15 ,P0(P5)<-P8  ---- SW - P8 P5 0 - 5 - - ---- 003 - - 1 0 1 |PC OP Pi EFAD C1|
010] ADDI R1,R1,4  3 4 5 6 6 7 15 P9,P5,4  ---- ADDI P9 P5 - 4 5 - - ---- 004 R1 P5 0 0 1 |---- SW P0 1000 12|
011] BNE  R2,R0,-6  3 4 5 7 7 8 15 ,P7,P0,-6  ---- BNE - P7 P0 -6 - 5 - - ---- 005 - - 0 0 1 |---- SW P0 1004 14|
012] LW  R2,0(R1)  4 5 6 7 8 10      P10,0(P9)  ---- LW P10 P9 - 0 7 - - 012) 000 R2 P7 0 0 1 |015] SW P0 1008 .|
013] ADDI R2,R2,1  4 5 6 10 10 11      P11,P10,1      ---- ADDI P11 P10 - 1 10 - - 013) 001 R2 P10 0 0 1 +-----+
014] MUL  R4,R2,R2  4 5 6 11 11      P12,P11,P11     ---- MUL P12 P11 P11 - 11 11 - 014) 002 R4 P8 0 0 0
015] SW   R4,0(R1)  4 5 6  8  9      ,P0(P9)<-P12     ---- SW - P12 P9 0 - 7 - 015) 003 - - 1 0 0
016] ADDI R1,R1,4  5 8 9 10 10 11      P2,P9,4       ---- ADDI P2 P9 - 4 9 - - 016) 004 R1 P9 0 0 1
017] BNE  R2,R0,-6  5 8 9 10 10 11      ,P11,P0,-6      ---- BNE - P11 P0 -6 - 9 - 017) 005 - - 0 0 1

----- Press ENTER to continue (PC=7,IC=18,CK=15,CTOT=16,IPC=1.12)...
```

```
=====
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12
                *                * * * * *
qi:  1  0  1  1  1  1  1  0  0  1  0  0
vi:  00 0C 01 01 04 00 01 01 08 00 01 01

=====
REG.FILE: Ri:      1      2      3      4      5      6      7      8
          Pi:      2      11     -      12     -      -      -      -
          Qi:      0      0      0      0      0      0      0      0
          Vi: 00001004 00000000 00003000 00000001 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 12          8                    99                    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 2 0 25 0 0 5 2            0                    0                    0 0 0 2 0 0 0

=====
PC INSTRUCTION    F D P I X W C Pi,Pj Pk P1  IW#  OPCODE Pi Pj Pk I/P1  Cj Ck Cl  ROB# PC Ri oPi x s 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] ADDI R2,R2,1  0 1 2 6 6 7 8 P3,P2,1  ---- ADDI P3 P2 - 1 6 - - ---- 001 R2 P2 0 0 1 |PC OP Pi EFAD Ci|
002] MUL  R4,R2,R2  0 1 2 7 7 12 13 P4,P3,P3  ---- MUL P4 P3 P3 - 7 7 - - ---- 002 R4 - 0 0 1 |---- LW P2 1000 6|
003] SW   R4,0(R1)  0 1 2 4 5 12 13 ,P0(P1)<-P4  ---- SW - P4 P1 0 - 2 - - ---- 003 - - 1 0 1 |---- LW P6 1004 8|
```

11

Press ENTER to continue (PC=7,IC=18,CK=16,CTOT=17,IPC=1.06)...

REG. FILE:	Ri:	1	2	3	4	5	6	7	8
	Pi:	2	11	-	12	-	-	-	-
	Qi:	0	0	0	0	0	0	0	0
	Vi:	00001008	00000000	00003000	00000001	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	12	8	99	4	1	1	0	1	4	1
BUSY SLOTS:	0	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0
STALLS:	0	2	0	25	0	0	5	2	0	0	0	0	2	0	0	0	0

PC	INSTRUCTION	F	D	P	I	W	C	Pi	Pj	Pk	P1	IW#	OPCD	Pi	Pj	Pk	I/P1	Cj	Ck	C1	ROB#	PC	Ri	oPi	x	s	c		
0001	LW R2,0(R1)	0	1	2	3	4	6	7	P2,0(P1)	----	----	----	LW	P2	P1	-	0	2	-	-	----	000	R1	-	0	0	1		LQ(0)
0011	ADDI R2,R2,1	0	1	2	6	7	8	P3,P2,1	----	----	----	ADDI	P3	P2	-	1	6	-	-	----	001	R2	P2	0	0	1		PC OP Pi EFAD Ci	
0021	MUL R4,R2,R1	0	1	2	7	12	13	P4,P3,P3	----	----	----	MUL	P4	P3	P3	-	7	7	-	----	002	R4	-	0	0	1		----- LW P2 1000 6	
0031	SW R4,0(R1)	0	1	2	4	5	12	13	P0(P1)<-P4	----	----	----	SW	-	P4	P1	0	-	2	-	----	003	-	-	1	0	1		----- LW P6 1004 8
0041	ADDI R1,R1,4	1	2	3	4	4	5	P5,P1,4	----	----	----	ADDI	P5	P1	-	4	3	-	-	----	004	R1	P1	0	0	1		----- LW P10 1008 10	
0051	BNE R2,R0,-6	1	2	3	4	4	5	P3,P0,-6	----	----	----	BNE	-	P3	P0	-6	-	3	-	----	005	-	-	0	0	1		-----	
0061	LW R2,0(R1)	2	3	4	5	6	8	P4,P6,0(P5)	----	----	----	LW	P6	P5	-	0	5	-	-	----	000	R2	P3	0	0	1		-----	
0071	ADDI R2,R2,1	2	3	4	8	8	9	P7,P6,1	----	----	----	ADDI	P7	P6	-	1	8	-	-	----	001	R2	P6	0	0	1		-----	
0081	MUL R4,R2,R1	2	3	4	9	9	14	P8,P7,P7	----	----	----	MUL	P8	P7	P7	-	9	9	-	----	002	R4	P4	0	0	1		SQ(0)	
0091	SW R4,0(R1)	2	3	4	6	7	14	P5,P0(P5)<-P8	----	----	----	SW	-	P8	P5	0	-	5	-	----	003	-	-	1	0	1		PC OP Pi EFAD Ci	
0101	ADDI R1,R1,4	3	4	5	6	6	7	P9,P5,4	----	----	----	ADDI	P9	P5	-	4	5	-	-	----	004	R1	P5	0	0	1		----- SW P0 1000 12	
0111	BNE R2,R0,-6	3	4	5	7	7	8	P5,P7,P0,-6	----	----	----	BNE	-	P7	P0	-6	-	5	-	----	005	-	-	0	0	1		----- SW P0 1004 14	
0121	LW R2,0(R1)	4	5	6	7	8	10	P10,0(P9)	----	----	----	LW	P10	P9	-	0	7	-	-	----	000	R2	P7	0	0	1		----- SW P0 1008 16	
0131	ADDI R2,R2,1	4	5	6	10	10	11	P11,P10,1	----	----	----	ADDI	P11	P10	-	1	10	-	-	----	001	R2	P10	0	0	1		-----	
0141	MUL R4,R2,R2	4	5	6	11	11	16	P12,P11,P11	----	----	----	MUL	P12	P11	P11	-	11	11	-	----	002	R4	P8	0	0	1		-----	
0151	SW R4,0(R1)	4	5	6	8	9	16	P7,P0(P9)<-P12	----	----	----	SW	-	P12	P9	0	-	7	-	----	003	-	-	1	0	1		-----	
0161	ADDI R1,R1,4	5	8	9	10	10	11	P2,P9,4	----	----	----	ADDI	P2	P9	-	4	9	-	-	----	004	R1	P9	0	0	1		-----	
0171	BNE R2,R0,-6	5	8	9	10	10	11	P11,P0,-6	----	----	----	BNE	-	P11	P0	-6	-	9	-	----	005	-	-	0	0	1		-----	

Press ENTER to continue (PC=7,IC=18,CK=17,CTOT=18,IPC=1.00)...

Goodbye .