```
./run151106.sh
TEST DATE: 151106

LIST OF INITALIZATION PARAMETERS
---------------------------------------------[General]
Program Name           = prog151106
Silent                 = no
Interactive            = no
Batch File             = yes
---------------------------------------------[Architecture]
Logical Registers      = 8
Physical Registers     = 18
Pipeline Structure     = FDPIXWC
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            = 3
ROB Size               = 99
Integer ALU Units      = 4
Intger 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: 'prog151106'
  R1 <-- 00000000
  000) 35  2  1  0 --> LW   R2,0(R1)
  001) 24  2  2  2 --> MUL  R2,R2,R2
  002) 43  2  1  0 --> SW   R2,0(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 = 3 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, all registers contain zero.

                lab1:   LW   R2,0(R1)
                        MUL  R2,R2,R2
                        SW   R2,0(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 3 slots
* we have 18 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 13 14 15 16 17 18

         qi:   1  1  1  1  1  1  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 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:  00000000 00000000 00000000 00000000 00000000 00000000 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  3  4 12  4  4 18             3                                 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#  OPCD Pi  Pj  Pk I/Pl  Cj Ck Cl  ROB# PC  Ri  oPi x s c  +------------------+
000] LW   R2,0(R1)      0                                                                                                 |LQ(0 )            |
001] MUL  R2,R2,R2      0                                                                                                 |PC   OP Pi  EFAD Ci|
002] SW   R2,0(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  9 10 11 12 13 14 15 16 17 18
                *  *  *  *
         qi:   0  1  1  1  1  1  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 00 00 00 00 00 00
================================================================================================================================================
REG.FILE: Ri:         1        2        3        4        5        6        7        8
          Pi:         4        3        -        -        -        -        -        -
          Qi:         1        1        0        0        0        0        0        0
          Vi:  00000000 00000000 00000000 00000000 00000000 00000000 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  3  4 12  4  4 18             3                                 99                       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 Pi,Pj Pk Pl    IW#  OPCD 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)                                                                       |LQ(0 )            |
001] MUL  R2,R2,R2      0  1               P3,P2,P2                                                                       |PC   OP Pi  EFAD Ci|
002] SW   R2,0(R1)      0  1               ,P0(P1)<-P3                                                                    +------------------+
003] ADDI R1,R1,4       0  1               P4,P1,4
004] BNE  R2,R0,-5      1                                                                                                 +------------------+
------------------------------------------------- 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  9 10 11 12 13 14 15 16 17 18
                *  *  *  *
         qi:   0  1  1  1  1  1  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 00 00 00 00 00 00
```

```
================================================================================================================================================
REG.FILE: Ri:         1        2        3        4        5        6        7        8
          Pi:         4        3        -        -        -        -        -        -
          Qi:         1        1        0        0        0        0        0        0
          Vi:  00000000 00000000 00000000 00000000 00000000 00000000 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  3  4 12  4  4 18             3                                 99                       4  1  1  0  1  4  1
BUSY SLOTS:            4  2  3  0  0  0  0 4              3                                 3                        0  0  0  0  0  0  0
STALLS:                0  0  1  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/Pl  Cj Ck Cl  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] MUL  R2,R2,R2     0  1  2            P3,P2,P2       001)  MUL P3  P2  P2  -    .  .  -   001) 001 R2  P2  0 0 0  |PC   OP Pi  EFAD Ci|
002] SW   R2,0(R1)     0  1  2            ,P0(P1)<-P3    002)   SW -   P3  P1  0    -  2  -   002) 002 -   -   1 0 0  +------------------+
003] ADDI R1,R1,4      0  1               P4,P1,4
004] BNE  R2,R0,-5     1  2               ,P3,P0,-5                                                                   +------------------+
005] LW   R2,0(R1)     2                                                                                              |SQ(0 )            |
006] MUL  R2,R2,R2     2                                                                                              |PC   OP Pi  EFAD Cl|
007] SW   R2,0(R1)     2                                                                                              +------------------+
008] ADDI R1,R1,4      2
------------------------------------------------ Press ENTER to continue (PC=4,IC=9,CK=2,CTOT=3,IPC=3.00)...
@002 stall due to NO SLOTS when trying to move instuction ADDI/003 from stage D to stage P.


================================================================================================================================================
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18
                *  *  *  *  *  *
          qi:   0  1  1  1  1  1  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 00 00 00 00 00 00
================================================================================================================================================
REG.FILE: Ri:         1        2        3        4        5        6        7        8
          Pi:         4        6        -        -        -        -        -        -
          Qi:         1        1        0        0        0        0        0        0
          Vi:  00000000 00000000 00000000 00000000 00000000 00000000 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  3  4 12  4  4 18             3                                 99                       4  1  1  0  1  4  1
BUSY SLOTS:            2  4  3  1  0  0  0 6              3                                 4                        0  0  0  0  0  0  0
STALLS:                0  1  2  2  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 Pl    IW#  OPCD Pi  Pj  Pk I/Pl  Cj Ck Cl  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] MUL  R2,R2,R2     0  1  2            P3,P2,P2       001)  MUL P3  P2  P2  -    .  .  -   001) 001 R2  P2  0 0 0  |PC   OP Pi  EFAD Ci|
002] SW   R2,0(R1)     0  1  2            ,P0(P1)<-P3    002)   SW -   P3  P1  0    -  2  -   002) 002 -   -   1 0 0  |000] LW P2  0000  .|
003] ADDI R1,R1,4      0  1  3            P4,P1,4        000) ADDI P4  P1  -   4    3  -  -   003) 003 R1  P1  0 0 0  +------------------+
004] BNE  R2,R0,-5     1  2               ,P3,P0,-5
005] LW   R2,0(R1)     2  3               P5,0(P4)                                                                    +------------------+
006] MUL  R2,R2,R2     2  3               P6,P5,P5                                                                    |SQ(0 )            |
007] SW   R2,0(R1)     2  3               ,P0(P4)<-P6                                                                 |PC   OP Pi  EFAD Cl|
008] ADDI R1,R1,4      2                                                                                              +------------------+
009] BNE  R2,R0,-5     3
------------------------------------------------ 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 instuction 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 instuction SW/002 from stage P to stage I.
@003 stall due to NO SLOTS when trying to move instuction BNE/004 from stage D to stage P.
@003 stall due to NO SLOTS when trying to move instuction ADDI/008 from stage F to stage D.


================================================================================================================================================
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18
                *  *  *  *  *  *  *
          qi:   0  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
          vi:  00 00 00 04 00 00 00 00 00 00 00 00 00 00 00 00 00 00
================================================================================================================================================
REG.FILE: Ri:         1        2        3        4        5        6        7        8
          Pi:         7        6        -        -        -        -        -        -
          Qi:         1        1        0        0        0        0        0        0
          Vi:  00000000 00000000 00000000 00000000 00000000 00000000 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  3  4 12  4  4 18            3                                  99                       4  1  1  0  1  4  1
BUSY SLOTS:            4  4  3  1  2  0  0 7             3                                  6                        0  0  0  0  0  0  0
STALLS:                0  1  4  3  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 Pl    IW#  OPCD 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      P2,0(P1)       ----   LW P2  P1  -   0    2  -  -   000) 000 R2  -   0 0 0  |LQ(1 )            |
001] MUL  R2,R2,R2     0  1  2            P3,P2,P2       001)  MUL P3  P2  P2  -    .  .  -   001) 001 R2  P2  0 0 0  |PC   OP Pi  EFAD Ci|
002] SW   R2,0(R1)     0  1  2  4         ,P0(P1)<-P3    002>   SW -   P3  P1  0    -  2  -   002) 002 -   -   1 0 0  |000] LW P2  0000  .|
003] ADDI R1,R1,4      0  1  3  4  4      P4,P1,4        000> ADDI P4  P1  -   4    3  -  -   003) 003 R1  P1  0 0 0  +------------------+
004] BNE  R2,R0,-5     1  2  4            ,P3,P0,-5      000)  BNE -   P3  P0  -5   -  4  -   004) 004 -   -   0 0 0
005] LW   R2,0(R1)     2  3  4            P5,0(P4)       002)   LW P5  P4  -   0    .  -  -   005) 000 R2  P3  0 0 0  +------------------+
006] MUL  R2,R2,R2     2  3               P6,P5,P5                                                                    |SQ(1 )            |
007] SW   R2,0(R1)     2  3               ,P0(P4)<-P6                                                                 |PC   OP Pi  EFAD Cl|
008] ADDI R1,R1,4      2  4               P7,P4,4                                                                     |002] SW P0  0000  .|
009] BNE  R2,R0,-5     3  4               ,P6,P0,-5                                                                   +------------------+
010] LW   R2,0(R1)     4
011] MUL  R2,R2,R2     4
012] SW   R2,0(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 instuction MUL/001 from stage P to stage I.
@004 stall due to NO SLOTS when trying to move instuction MUL/006 from stage D to stage P.
@004 stall due to NO SLOTS when trying to move instuction SW/007 from stage D to stage P.


=============================================================================================================================
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18
                *  *  *  *  *  *  *  *  *
          qi:   0  1  1  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1
          vi:  00 00 00 04 00 00 00 00 00 00 00 00 00 00 00 00 00 00
=============================================================================================================================
REG.FILE: Ri:         1        2        3        4        5        6        7        8
          Pi:         7        9        -        -        -        -        -
          Qi:         1        1        0        0        0        0        0        0
          Vi:  00000004 00000000 00000000 00000000 00000000 00000000 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  3  4 12  4  4 18            3                                  99                       4  1  1  0  1  4  1
BUSY SLOTS:            3  4  3  1  2  1  0 9             3                                  8                        0  0  0  0  0  0  0
STALLS:                0  3  6  4  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 Pl    IW#  OPCD 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      P2,0(P1)       ----   LW P2  P1  -   0    2  -  -   000) 000 R2  -   0 0 0  |LQ(2 )            |
001] MUL  R2,R2,R2     0  1  2            P3,P2,P2       001)  MUL P3  P2  P2  -    .  .  -   001) 001 R2  P2  0 0 0  |PC   OP Pi  EFAD Ci|
002] SW   R2,0(R1)     0  1  2  4  5      ,P0(P1)<-P3    ----   SW -   P3  P1  0    -  2  -   002) 002 -   -   1 0 0  |000] LW P2  0000  .|
003] ADDI R1,R1,4      0  1  3  4  4  5   P4,P1,4        ---- ADDI P4  P1  -   4    3  -  -   003) 003 R1  P1  0 0 1  |005] LW P5  0000  5|
004] BNE  R2,R0,-5     1  2  4  5  5      ,P3,P0,-5      000>  BNE -   P3  P0  -5   -  4  -   004) 004 -   -   0 0 0  +------------------+
005] LW   R2,0(R1)     2  3  4  5         P5,0(P4)       002>   LW P5  P4  -   0    5  -  -   005) 000 R2  P3  0 0 0
006] MUL  R2,R2,R2     2  3  5            P6,P5,P5       000)  MUL P6  P5  P5  -    .  .  -   006) 001 R2  P5  0 0 0  +------------------+
007] SW   R2,0(R1)     2  3  5            ,P0(P4)<-P6    002)   SW -   P6  P4  0    -  5  -   007) 002 -   -   1 0 0  |SQ(1 )            |
008] ADDI R1,R1,4      2  4               P7,P4,4                                                                     |PC   OP Pi  EFAD Cl|
009] BNE  R2,R0,-5     3  4               ,P6,P0,-5                                                                   |002] SW P0  0000  .|
010] LW   R2,0(R1)     4  5               P8,0(P7)                                                                    +------------------+
011] MUL  R2,R2,R2     4  5               P9,P8,P8
012] SW   R2,0(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 instuction MUL/001 from stage P to stage I.
@005 stall due to NO SLOTS when trying to move instuction ADDI/008 from stage D to stage P.
@005 stall due to NO SLOTS when trying to move instuction BNE/009 from stage D to stage P.
@005 stall due to NO SLOTS when trying to move instuction SW/012 from stage F to stage D.
@005 stall due to NO SLOTS when trying to move instuction ADDI/013 from stage F to stage D.


=============================================================================================================================
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18
                *  *  *  *  *  *  *  *  *  *
          qi:   0  0  1  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1
```

```
         vi:  00 00 00 04 00 00 00 00 00 00 00 00 00 00 00 00 00 00
================================================================================================================================================
REG.FILE: Ri:         1        2        3        4        5        6        7        8
          Pi:        10        9        -        -        -        -        -        -
          Qi:         1        1        0        0        0        0        0        0
          Vi:  00000004 00000000 00000000 00000000 00000000 00000000 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  3  4 12  4  4 18            3                                  99                       4  1  1  0  1  4  1
BUSY SLOTS:             1  4  3  1  2  1  0 10            3                                  10                       0  0  0  0  0  0  0
STALLS:                 0  4  8  5  0  0  1 0             0                                  0                        0  0  0  1  0  0  0
================================================================================================================================================
PC   INSTRUCTION        F  D  P  I  X  W  C Pi,Pj Pk Pl    IW#  OPCD 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] MUL  R2,R2,R2      0  1  2  6  6       P3,P2,P2       001>  MUL P3  P2  P2  -    6  6  -   001) 001 R2  P2  0 0 0  |PC   OP Pi  EFAD Ci|
002] SW   R2,0(R1)      0  1  2  4  5       ,P0(P1)<-P3    ----   SW -   P3  P1  0    -  2  -   002) 002 -   -   1 0 0  |---- LW P2  0000  6|
003] ADDI R1,R1,4       0  1  3  4  4  5    P4,P1,4        ---- ADDI P4  P1  -   4    3  -  -   003) 003 R1  P1  0 0 1  |005] LW P5  0004  5|
004] BNE  R2,R0,-5      1  2  4  5  5  6    ,P3,P0,-5      ----  BNE -   P3  P0  -5   -  4  -   004) 004 -   -   0 0 1  +------------------+
005] LW   R2,0(R1)      2  3  4  5  6       P5,0(P4)       ----   LW P5  P4  -   0    5  -  -   005) 000 R2  P3  0 0 0
006] MUL  R2,R2,R2      2  3  5             P6,P5,P5       000)  MUL P6  P5  P5  -    .  .  -   006) 001 R2  P5  0 0 0  +------------------+
007] SW   R2,0(R1)      2  3  5  6          ,P0(P4)<-P6    002>   SW -   P6  P4  0    -  5  -   007) 002 -   -   1 0 0  |SQ(2 )            |
008] ADDI R1,R1,4       2  4  6             P7,P4,4        001) ADDI P7  P4  -   4    6  -  -   008) 003 R1  P4  0 0 0  |PC   OP Pi  EFAD Cl|
009] BNE  R2,R0,-5      3  4  6             ,P6,P0,-5      002)  BNE -   P6  P0  -5   -  6  -   009) 004 -   -   0 0 0  |002] SW P0  0000  .|
010] LW   R2,0(R1)      4  5                P8,0(P7)                                                                    |007] SW P0  0000  .|
011] MUL  R2,R2,R2      4  5                P9,P8,P8                                                                    +------------------+
012] SW   R2,0(R1)      4  6                ,P0(P7)<-P9
013] ADDI R1,R1,4       4  6                P10,P7,4
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 instuction ADDI/003 from stage W to stage C.
@006 stall due to NO SLOTS when trying to move instuction MUL/006 from stage P to stage I.
@006 stall due to NO SLOTS when trying to move instuction LW/010 from stage D to stage P.
@006 stall due to NO SLOTS when trying to move instuction MUL/011 from stage D to stage P.
@006 stall due to NO SLOTS when trying to move instuction BNE/014 from stage F to stage D.

================================================================================================================================================
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18
                *  *  *  *  *  *  *  *  *  *
          qi:   0  0  1  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1
          vi:  00 00 00 04 00 00 08 00 00 00 00 00 00 00 00 00 00 00
================================================================================================================================================
REG.FILE: Ri:         1        2        3        4        5        6        7        8
          Pi:        10        9        -        -        -        -        -        -
          Qi:         1        1        0        0        0        0        0        0
          Vi:  00000004 00000000 00000000 00000000 00000000 00000000 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  3  4 12  4  4 18            3                                  99                       4  1  1  0  1  4  1
BUSY SLOTS:             0  3  3  0  4  0  0 10            3                                  11                       0  0  0  0  0  0  0
STALLS:                 0  4 10  6  0  0  1 0             0                                  0                        0  0  0  1  0  0  0
================================================================================================================================================
PC   INSTRUCTION        F  D  P  I  X  W  C Pi,Pj Pk Pl    IW#  OPCD 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(1 )            |
001] MUL  R2,R2,R2      0  1  2  6  6       P3,P2,P2       ----  MUL P3  P2  P2  -    6  6  -   001) 001 R2  P2  0 0 0  |PC   OP Pi  EFAD Ci|
002] SW   R2,0(R1)      0  1  2  4  5       ,P0(P1)<-P3    ----   SW -   P3  P1  0    -  2  -   002) 002 -   -   1 0 0  |---- LW P2  0000  6|
003] ADDI R1,R1,4       0  1  3  4  4  5    P4,P1,4        ---- ADDI P4  P1  -   4    3  -  -   003) 003 R1  P1  0 0 1  |005] LW P5  0004  5|
004] BNE  R2,R0,-5      1  2  4  5  5  6    ,P3,P0,-5      ----  BNE -   P3  P0  -5   -  4  -   004) 004 -   -   0 0 1  +------------------+
005] LW   R2,0(R1)      2  3  4  5  6       P5,0(P4)       ----   LW P5  P4  -   0    5  -  -   005) 000 R2  P3  0 0 0
006] MUL  R2,R2,R2      2  3  5             P6,P5,P5       000)  MUL P6  P5  P5  -    .  .  -   006) 001 R2  P5  0 0 0  +------------------+
007] SW   R2,0(R1)      2  3  5  6  7       ,P0(P4)<-P6    ----   SW -   P6  P4  0    -  5  -   007) 002 -   -   1 0 0  |SQ(2 )            |
008] ADDI R1,R1,4       2  4  6  7  7       P7,P4,4        001> ADDI P7  P4  -   4    6  -  -   008) 003 R1  P4  0 0 0  |PC   OP Pi  EFAD Cl|
009] BNE  R2,R0,-5      3  4  6  7  7       ,P6,P0,-5      002>  BNE -   P6  P0  -5   -  6  -   009) 004 -   -   0 0 0  |002] SW P0  0000  .|
010] LW   R2,0(R1)      4  5  7             P8,0(P7)       001)   LW P8  P7  -   0    .  -  -   010) 000 R2  P6  0 0 0  |007] SW P0  0004  .|
011] MUL  R2,R2,R2      4  5  7             P9,P8,P8       002)  MUL P9  P8  P8  -    .  .  -   011) 001 R2  P8  0 0 0  +------------------+
012] SW   R2,0(R1)      4  6                ,P0(P7)<-P9
013] ADDI R1,R1,4       4  6                P10,P7,4
014] BNE  R2,R0,-5      5  7                ,P9,P0,-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 instuction MUL/006 from stage P to stage I.
@007 stall due to NO SLOTS when trying to move instuction SW/012 from stage D to stage P.
@007 stall due to NO SLOTS when trying to move instuction ADDI/013 from stage D to stage P.
```

```
================================================================================================================================================
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18
                *  *  *  *  *  *  *  *  *  *
          qi:   0  0  1  0  0  1  0  1  1  1  1  1  1  1  1  1  1  1
          vi:  00 00 00 04 00 00 08 00 00 00 00 00 00 00 00 00 00 00
================================================================================================================================================
REG.FILE: Ri:         1        2        3        4        5        6        7        8
          Pi:        10        9        -        -        -        -        -        -
          Qi:         1        1        0        0        0        0        0        0
          Vi:  00000008 00000000 00000000 00000000 00000000 00000000 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  3  4 12  4  4 18             3                                   99                       4  1  1  0  1  4  1
BUSY SLOTS:             0  1  3  1  2  1  0 10             3                                   13                       0  0  0  0  0  0  0
STALLS:                 0  4 11  7  0  0  2 0              0                                   0                        0  0  0  1  0  0  0
================================================================================================================================================
PC   INSTRUCTION        F  D  P  I  X  W  C Pi,Pj Pk Pl    IW#  OPCD 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(1 )            |
001] MUL  R2,R2,R2      0  1  2  6  6       P3,P2,P2       ----  MUL P3  P2  P2  -    6  6  -   001) 001 R2  P2  0 0 0  |PC   OP Pi  EFAD Ci|
002] SW   R2,0(R1)      0  1  2  4  5       ,P0(P1)<-P3    ----   SW -   P3  P1  0    -  2  -   002) 002 -   -   1 0 0  |---- LW P2  0000  6|
003] ADDI R1,R1,4       0  1  3  4  4  5     P4,P1,4        ---- ADDI P4  P1  -   4    3  -  -   003) 003 R1  P1  0 0 1  |---- LW P5  0004  8|
004] BNE  R2,R0,-5      1  2  4  5  5  6     ,P3,P0,-5      ----  BNE -   P3  P0  -5   -  4  -   004) 004 -   -   0 0 1  |010] LW P8  0000  8|
005] LW   R2,0(R1)      2  3  4  5  6  8     P5,0(P4)       ----   LW P5  P4  -   0    5  -  -   005) 000 R2  P3  0 0 1  +------------------+
006] MUL  R2,R2,R2      2  3  5  8  8        P6,P5,P5       000>  MUL P6  P5  P5  -    8  8  -   006) 001 R2  P5  0 0 0
007] SW   R2,0(R1)      2  3  5  6  7        ,P0(P4)<-P6    ----   SW -   P6  P4  0    -  5  -   007) 002 -   -   1 0 0  +------------------+
008] ADDI R1,R1,4       2  4  6  7  7  8     P7,P4,4        ---- ADDI P7  P4  -   4    6  -  -   008) 003 R1  P4  0 0 1  |SQ(2 )            |
009] BNE  R2,R0,-5      3  4  6  7  7  8     ,P6,P0,-5      ----  BNE -   P6  P0  -5   -  6  -   009) 004 -   -   0 0 1  |PC   OP Pi  EFAD Cl|
010] LW   R2,0(R1)      4  5  7  8           P8,0(P7)       001>   LW P8  P7  -   0    8  -  -   010) 000 R2  P6  0 0 0  |002] SW P0  0000  .|
011] MUL  R2,R2,R2      4  5  7              P9,P8,P8       002)  MUL P9  P8  P8  -    .  .  -   011) 001 R2  P8  0 0 0  |007] SW P0  0004  .|
012] SW   R2,0(R1)      4  6  8              ,P0(P7)<-P9    000)   SW -   P9  P7  0    -  8  -   012) 002 -   -   1 0 0  +------------------+
013] ADDI R1,R1,4       4  6  8              P10,P7,4       001) ADDI P10 P7  -   4    8  -  -   013) 003 R1  P7  0 0 0
014] BNE  R2,R0,-5      5  7                 ,P9,P0,-5
------------------------------------------------ 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 instuction BNE/004 from stage W to stage C.
@008 stall due to NO SLOTS when trying to move instuction MUL/011 from stage P to stage I.
@008 stall due to NO SLOTS when trying to move instuction BNE/014 from stage D to stage P.


================================================================================================================================================
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18
                *  *  *  *  *  *  *  *  *  *
          qi:   0  0  1  0  0  1  0  1  1  1  1  1  1  1  1  1  1  1
          vi:  00 00 00 04 00 00 08 00 00 0C 00 00 00 00 00 00 00 00
================================================================================================================================================
REG.FILE: Ri:         1        2        3        4        5        6        7        8
          Pi:        10        9        -        -        -        -        -        -
          Qi:         1        1        0        0        0        0        0        0
          Vi:  00000008 00000000 00000000 00000000 00000000 00000000 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  3  4 12  4  4 18             3                                   99                       4  1  1  0  1  4  1
BUSY SLOTS:             0  0  2  1  4  1  0 10             2                                   14                       0  0  0  0  0  0  0
STALLS:                 0  4 11  8  0  0  3 0              0                                   0                        0  0  0  1  0  0  0
================================================================================================================================================
PC   INSTRUCTION        F  D  P  I  X  W  C Pi,Pj Pk Pl    IW#  OPCD 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(1 )            |
001] MUL  R2,R2,R2      0  1  2  6  6       P3,P2,P2       ----  MUL P3  P2  P2  -    6  6  -   001) 001 R2  P2  0 0 0  |PC   OP Pi  EFAD Ci|
002] SW   R2,0(R1)      0  1  2  4  5       ,P0(P1)<-P3    ----   SW -   P3  P1  0    -  2  -   002) 002 -   -   1 0 0  |---- LW P2  0000  6|
003] ADDI R1,R1,4       0  1  3  4  4  5     P4,P1,4        ---- ADDI P4  P1  -   4    3  -  -   003) 003 R1  P1  0 0 1  |---- LW P5  0004  8|
004] BNE  R2,R0,-5      1  2  4  5  5  6     ,P3,P0,-5      ----  BNE -   P3  P0  -5   -  4  -   004) 004 -   -   0 0 1  |010] LW P8  0008  8|
005] LW   R2,0(R1)      2  3  4  5  6  8     P5,0(P4)       ----   LW P5  P4  -   0    5  -  -   005) 000 R2  P3  0 0 1  +------------------+
006] MUL  R2,R2,R2      2  3  5  8  8        P6,P5,P5       ----  MUL P6  P5  P5  -    8  8  -   006) 001 R2  P5  0 0 0
007] SW   R2,0(R1)      2  3  5  6  7        ,P0(P4)<-P6    ----   SW -   P6  P4  0    -  5  -   007) 002 -   -   1 0 0  +------------------+
008] ADDI R1,R1,4       2  4  6  7  7  8     P7,P4,4        ---- ADDI P7  P4  -   4    6  -  -   008) 003 R1  P4  0 0 1  |SQ(3 )            |
009] BNE  R2,R0,-5      3  4  6  7  7  8     ,P6,P0,-5      ----  BNE -   P6  P0  -5   -  6  -   009) 004 -   -   0 0 1  |PC   OP Pi  EFAD Cl|
010] LW   R2,0(R1)      4  5  7  8  9        P8,0(P7)       ----   LW P8  P7  -   0    8  -  -   010) 000 R2  P6  0 0 0  |002] SW P0  0000  .|
011] MUL  R2,R2,R2      4  5  7              P9,P8,P8       002)  MUL P9  P8  P8  -    .  .  -   011) 001 R2  P8  0 0 0  |007] SW P0  0004  .|
012] SW   R2,0(R1)      4  6  8  9           ,P0(P7)<-P9    000>   SW -   P9  P7  0    -  8  -   012) 002 -   -   1 0 0  |012] SW P0  0000  .|
```

```
013] ADDI R1,R1,4       4  6  8  9  9       P10,P7,4       001> ADDI P10 P7  -   4    8  -  -   013) 003 R1  P7  0 0 0  +------------------+
014] BNE  R2,R0,-5      5  7  9             ,P9,P0,-5      000)  BNE -   P9  P0  -5   -  9  -   014) 004 -   -   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 instuction BNE/009 from stage W to stage C.
@009 stall due to NO SLOTS when trying to move instuction MUL/011 from stage P to stage I.

================================================================================================================================================
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18
                *  *  *  *  *  *  *  *  *  *
          qi:   0  0  1  0  0  1  0  1  1  0  1  1  1  1  1  1  1  1
          vi:  00 00 00 04 00 00 08 00 00 0C 00 00 00 00 00 00 00 00
================================================================================================================================================
REG.FILE: Ri:         1        2        3        4        5        6        7        8
          Pi:        10        9        -        -        -        -        -        -
          Qi:         0        1        0        0        0        0        0        0
          Vi:  0000000C 00000000 00000000 00000000 00000000 00000000 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  3  4 12  4  4 18             3                                   99                       4  1  1  0  1  4  1
BUSY SLOTS:             0  0  1  0  4  1  0 10             1                                   14                       0  0  0  0  0  0  0
STALLS:                 0  4 11  9  0  0  4 0              0                                   0                        0  0  0  1  0  0  0
================================================================================================================================================
PC   INSTRUCTION        F  D  P  I  X  W  C Pi,Pj Pk Pl    IW#  OPCD 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(1 )            |
001] MUL  R2,R2,R2      0  1  2  6  6       P3,P2,P2       ----  MUL P3  P2  P2  -    6  6  -   001) 001 R2  P2  0 0 0  |PC   OP Pi  EFAD Ci|
002] SW   R2,0(R1)      0  1  2  4  5       ,P0(P1)<-P3    ----   SW -   P3  P1  0    -  2  -   002) 002 -   -   1 0 0  |---- LW P2  0000  6|
003] ADDI R1,R1,4       0  1  3  4  4  5    P4,P1,4        ---- ADDI P4  P1  -   4    3  -  -   003) 003 R1  P1  0 0 1  |---- LW P5  0004  8|
004] BNE  R2,R0,-5      1  2  4  5  5  6    ,P3,P0,-5      ----  BNE -   P3  P0  -5   -  4  -   004) 004 -   -   0 0 1  |010] LW P8  0008  8|
005] LW   R2,0(R1)      2  3  4  5  6  8    P5,0(P4)       ----   LW P5  P4  -   0    5  -  -   005) 000 R2  P3  0 0 1  +------------------+
006] MUL  R2,R2,R2      2  3  5  8  8       P6,P5,P5       ----  MUL P6  P5  P5  -    8  8  -   006) 001 R2  P5  0 0 0
007] SW   R2,0(R1)      2  3  5  6  7       ,P0(P4)<-P6    ----   SW -   P6  P4  0    -  5  -   007) 002 -   -   1 0 0  +------------------+
008] ADDI R1,R1,4       2  4  6  7  7  8    P7,P4,4        ---- ADDI P7  P4  -   4    6  -  -   008) 003 R1  P4  0 0 1  |SQ(3 )            |
009] BNE  R2,R0,-5      3  4  6  7  7  8    ,P6,P0,-5      ----  BNE -   P6  P0  -5   -  6  -   009) 004 -   -   0 0 1  |PC   OP Pi  EFAD Cl|
010] LW   R2,0(R1)      4  5  7  8  9       P8,0(P7)       ----   LW P8  P7  -   0    8  -  -   010) 000 R2  P6  0 0 0  |002] SW P0  0000  .|
011] MUL  R2,R2,R2      4  5  7             P9,P8,P8       002)  MUL P9  P8  P8  -    .  .  -   011) 001 R2  P8  0 0 0  |007] SW P0  0004  .|
012] SW   R2,0(R1)      4  6  8  9 10       ,P0(P7)<-P9    ----   SW -   P9  P7  0    -  8  -   012) 002 -   -   1 0 0  |012] SW P0  0008  .|
013] ADDI R1,R1,4       4  6  8  9  9 10    P10,P7,4       ---- ADDI P10 P7  -   4    8  -  -   013) 003 R1  P7  0 0 1  +------------------+
014] BNE  R2,R0,-5      5  7  9 10 10       ,P9,P0,-5      000>  BNE -   P9  P0  -5   -  9  -   014) 004 -   -   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 instuction BNE/009 from stage W to stage C.
@010 stall due to NO SLOTS when trying to move instuction MUL/011 from stage P to stage I.



================================================================================================================================================
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18
                *  *  *  *  *  *  *  *  *  *
          qi:   0  0  0  0  0  1  0  0  1  0  1  1  1  1  1  1  1  1
          vi:  00 00 00 04 00 00 08 00 00 0C 00 00 00 00 00 00 00 00
================================================================================================================================================
REG.FILE: Ri:         1        2        3        4        5        6        7        8
          Pi:        10        9        -        -        -        -        -        -
          Qi:         0        1        0        0        0        0        0        0
          Vi:  0000000C 00000000 00000000 00000000 00000000 00000000 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  3  4 12  4  4 18             3                                   99                       4  1  1  0  1  4  1
BUSY SLOTS:             0  0  0  0  2  1  0 10             0                                   14                       0  0  0  0  0  0  0
STALLS:                 0  4 11  9  0  0  5 0              0                                   0                        0  0  0  1  0  0  0
================================================================================================================================================
PC   INSTRUCTION        F  D  P  I  X  W  C Pi,Pj Pk Pl    IW#  OPCD 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(0 )            |
001] MUL  R2,R2,R2      0  1  2  6  6 11    P3,P2,P2       ----  MUL P3  P2  P2  -    6  6  -   001) 001 R2  P2  0 0 1  |PC   OP Pi  EFAD Ci|
002] SW   R2,0(R1)      0  1  2  4  5 11    ,P0(P1)<-P3    ----   SW -   P3  P1  0    -  2  -   002) 002 -   -   1 0 1  |---- LW P2  0000  6|
003] ADDI R1,R1,4       0  1  3  4  4  5    P4,P1,4        ---- ADDI P4  P1  -   4    3  -  -   003) 003 R1  P1  0 0 1  |---- LW P5  0004  8|
004] BNE  R2,R0,-5      1  2  4  5  5  6    ,P3,P0,-5      ----  BNE -   P3  P0  -5   -  4  -   004) 004 -   -   0 0 1  |---- LW P8  0008 11|
005] LW   R2,0(R1)      2  3  4  5  6  8    P5,0(P4)       ----   LW P5  P4  -   0    5  -  -   005) 000 R2  P3  0 0 1  +------------------+
006] MUL  R2,R2,R2      2  3  5  8  8       P6,P5,P5       ----  MUL P6  P5  P5  -    8  8  -   006) 001 R2  P5  0 0 0
007] SW   R2,0(R1)      2  3  5  6  7       ,P0(P4)<-P6    ----   SW -   P6  P4  0    -  5  -   007) 002 -   -   1 0 0  +------------------+
008] ADDI R1,R1,4       2  4  6  7  7  8    P7,P4,4        ---- ADDI P7  P4  -   4    6  -  -   008) 003 R1  P4  0 0 1  |SQ(2 )            |
009] BNE  R2,R0,-5      3  4  6  7  7  8    ,P6,P0,-5      ----  BNE -   P6  P0  -5   -  6  -   009) 004 -   -   0 0 1  |PC   OP Pi  EFAD Cl|
```

```
010] LW   R2,0(R1)      4  5  7  8  9 11    P8,0(P7)       ----   LW P8  P7  -   0    8  -  -   010) 000 R2  P6  0 0 1  |---- SW P0  0000 11|
011] MUL  R2,R2,R2      4  5  7 11 11       P9,P8,P8       002>  MUL P9  P8  P8  -   11 11  -   011) 001 R2  P8  0 0 0  |007] SW P0  0004  .|
012] SW   R2,0(R1)      4  6  8  9 10       ,P0(P7)<-P9    ----   SW -   P9  P7  0    -  8  -   012) 002 -   -   1 0 0  |012] SW P0  0008  .|
013] ADDI R1,R1,4       4  6  8  9 10       P10,P7,4       ---- ADDI P10 P7  -   4    8  -  -   013) 003 R1  P7  0 0 1  +-------------------+
014] BNE  R2,R0,-5      5  7  9 10 10 11    ,P9,P0,-5      ----  BNE -   P9  P0  -5   -  9  -   014) 004 -   -   0 0 1
------------------------------------------------ Press ENTER to continue (PC=6,IC=15,CK=11,CTOT=12,IPC=1.25)...
@011 stall due to NO SLOTS when trying to move instuction ADDI/013 from stage W to stage C.

================================================================================================================================================
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18
                   *  *  *  *  *  *  *  *

          qi:   1  1  0  0  0  1  0  0  1  0  1  1  1  1  1  1  1  1
          vi:  00 00 00 04 00 00 08 00 00 0C 00 00 00 00 00 00 00 00
================================================================================================================================================
REG.FILE: Ri:         1        2        3        4        5        6        7        8
          Pi:        10        9        -        -        -        -        -        -
          Qi:         0        1        0        0        0        0        0        0
          Vi:  00000000 00000000 00000000 00000000 00000000 00000000 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  3  4 12  4  4 18             3                                  99                       4  1  1  0  1  4  1
BUSY SLOTS:             0  0  0  0  2  1  0 8              0                                  10                       0  0  0  0  0  0  0
STALLS:                 0  4 11  9  0  0  5 0              0                                  0                        0  0  0  1  0  0  0
================================================================================================================================================
PC   INSTRUCTION        F  D  P  I  X  W  C Pi,Pj Pk Pl    IW#  OPCD 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(0 )             |
001] MUL  R2,R2,R2      0  1  2  6  6 11 12 P3,P2,P2       ----  MUL P3  P2  P2  -    6  6  -   ---- 001 R2  P2  0 0 1  |PC   OP Pi  EFAD Ci|
002] SW   R2,0(R1)      0  1  2  4  5 11 12 ,P0(P1)<-P3    ----   SW -   P3  P1  0    -  2  -   ---- 002 -   -   1 0 1  |---- LW P2  0000  6|
003] ADDI R1,R1,4       0  1  3  4  4  5 12 P4,P1,4        ---- ADDI P4  P1  -   4    3  -  -   ---- 003 R1  P1  0 0 1  |---- LW P5  0004  8|
004] BNE  R2,R0,-5      1  2  4  5  5  6 12 ,P3,P0,-5      ----  BNE -   P3  P0  -5   -  4  -   ---- 004 -   -   0 0 1  |---- LW P8  0008 11|
005] LW   R2,0(R1)      2  3  4  5  6  8    P5,0(P4)       ----   LW P5  P4  -   0    5  -  -   005) 000 R2  P3  0 0 1  +-------------------+
006] MUL  R2,R2,R2      2  3  5  8  8       P6,P5,P5       ----  MUL P6  P5  P5  -    8  8  -   006) 001 R2  P5  0 0 0
007] SW   R2,0(R1)      2  3  5  6  7       ,P0(P4)<-P6    ----   SW -   P6  P4  0    -  5  -   007) 002 -   -   1 0 0  +-------------------+
008] ADDI R1,R1,4       2  4  6  7  7  8    P7,P4,4        ---- ADDI P7  P4  -   4    6  -  -   008) 003 R1  P4  0 0 1  |SQ(2 )             |
009] BNE  R2,R0,-5      3  4  6  7  7  8    ,P6,P0,-5      ----  BNE -   P6  P0  -5   -  6  -   009) 004 -   -   0 0 1  |PC   OP Pi  EFAD Ci|
010] LW   R2,0(R1)      4  5  7  8  9 11    P8,0(P7)       ----   LW P8  P7  -   0    8  -  -   010) 000 R2  P6  0 0 1  |---- SW P0  0000 11|
011] MUL  R2,R2,R2      4  5  7 11 11       P9,P8,P8       ----  MUL P9  P8  P8  -   11 11  -   011) 001 R2  P8  0 0 0  |007] SW P0  0004  .|
012] SW   R2,0(R1)      4  6  8  9 10       ,P0(P7)<-P9    ----   SW -   P9  P7  0    -  8  -   012) 002 -   -   1 0 0  |012] SW P0  0008  .|
013] ADDI R1,R1,4       4  6  8  9  9 10    P10,P7,4       ---- ADDI P10 P7  -   4    8  -  -   013) 003 R1  P7  0 0 1  +-------------------+
014] BNE  R2,R0,-5      5  7  9 10 10 11    ,P9,P0,-5      ----  BNE -   P9  P0  -5   -  9  -   014) 004 -   -   0 0 1
------------------------------------------------ Press ENTER to continue (PC=6,IC=15,CK=12,CTOT=13,IPC=1.15)...


================================================================================================================================================
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18
                   *  *  *  *  *  *  *  *

          qi:   1  1  1  0  0  0  0  0  1  0  1  1  1  1  1  1  1  1
          vi:  00 00 00 04 00 00 08 00 00 0C 00 00 00 00 00 00 00 00
================================================================================================================================================
REG.FILE: Ri:         1        2        3        4        5        6        7        8
          Pi:        10        9        -        -        -        -        -        -
          Qi:         0        1        0        0        0        0        0        0
          Vi:  00000000 00000000 00000000 00000000 00000000 00000000 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  3  4 12  4  4 18             3                                  99                       4  1  1  0  1  4  1
BUSY SLOTS:             0  0  0  0  1  1  0 7              0                                  9                        0  0  0  0  0  0  0
STALLS:                 0  4 11  9  0  0  5 0              0                                  0                        0  0  0  1  0  0  0
================================================================================================================================================
PC   INSTRUCTION        F  D  P  I  X  W  C Pi,Pj Pk Pl    IW#  OPCD 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(0 )             |
001] MUL  R2,R2,R2      0  1  2  6  6 11 12 P3,P2,P2       ----  MUL P3  P2  P2  -    6  6  -   ---- 001 R2  P2  0 0 1  |PC   OP Pi  EFAD Ci|
002] SW   R2,0(R1)      0  1  2  4  5 11 12 ,P0(P1)<-P3    ----   SW -   P3  P1  0    -  2  -   ---- 002 -   -   1 0 1  |---- LW P2  0000  6|
003] ADDI R1,R1,4       0  1  3  4  4  5 12 P4,P1,4        ---- ADDI P4  P1  -   4    3  -  -   ---- 003 R1  P1  0 0 1  |---- LW P5  0004  8|
004] BNE  R2,R0,-5      1  2  4  5  5  6 12 ,P3,P0,-5      ----  BNE -   P3  P0  -5   -  4  -   ---- 004 -   -   0 0 1  |---- LW P8  0008 11|
005] LW   R2,0(R1)      2  3  4  5  6  8 13 P5,0(P4)       ----   LW P5  P4  -   0    5  -  -   ---- 000 R2  P3  0 0 1  +-------------------+
006] MUL  R2,R2,R2      2  3  5  8  8 13    P6,P5,P5       ----  MUL P6  P5  P5  -    8  8  -   006) 001 R2  P5  0 0 1
007] SW   R2,0(R1)      2  3  5  6  7 13    ,P0(P4)<-P6    ----   SW -   P6  P4  0    -  5  -   007) 002 -   -   1 0 1  +-------------------+
008] ADDI R1,R1,4       2  4  6  7  7  8    P7,P4,4        ---- ADDI P7  P4  -   4    6  -  -   008) 003 R1  P4  0 0 1  |SQ(1 )             |
009] BNE  R2,R0,-5      3  4  6  7  7  8    ,P6,P0,-5      ----  BNE -   P6  P0  -5   -  6  -   009) 004 -   -   0 0 1  |PC   OP Pi  EFAD Ci|
010] LW   R2,0(R1)      4  5  7  8  9 11    P8,0(P7)       ----   LW P8  P7  -   0    8  -  -   010) 000 R2  P6  0 0 1  |---- SW P0  0000 11|
```

```
011] MUL  R2,R2,R2      4  5  7 11 11       P9,P8,P8       ----  MUL P9  P8  P8  -   11 11  -   011) 001 R2  P8  0 0 0  |---- SW P0  0004 13|
012] SW   R2,0(R1)      4  6  8  9 10       ,P0(P7)<-P9    ----   SW -   P9  P7  0    -  8  -   012) 002 -   -   1 0 0  |012] SW P0  0008  .|
013] ADDI R1,R1,4       4  6  8  9  9 10    P10,P7,4       ---- ADDI P10 P7  -   4    8  -  -   013) 003 R1  P7  0 0 1  +-------------------+
014] BNE  R2,R0,-5      5  7  9 10 10 11    ,P9,P0,-5      ----  BNE -   P9  P0  -5   -  9  -   014) 004 -   -   0 0 1
------------------------------------------------- Press ENTER to continue (PC=6,IC=15,CK=13,CTOT=14,IPC=1.07)...

================================================================================================================================================
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18
                            *  *  *  *  *
         qi:   1  1  1  1  1  0  0  0  1  0  1  1  1  1  1  1  1  1
         vi:  00 00 00 04 00 00 08 00 00 0C 00 00 00 00 00 00 00 00
================================================================================================================================================
REG.FILE: Ri:         1        2        3        4        5        6        7        8
          Pi:        10        9        -        -        -        -        -        -
          Qi:         0        1        0        0        0        0        0        0
          Vi:  00000004 00000000 00000000 00000000 00000000 00000000 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  3  4 12  4  4 18             3                                   99                       4  1  1  0  1  4  1
BUSY SLOTS:             0  0  0  0  1  1  0 5              0                                   5                        0  0  0  0  0  0  0
STALLS:                 0  4 11  9  0  0  5 0              0                                   0                        0  0  0  1  0  0  0
================================================================================================================================================
PC   INSTRUCTION        F  D  P  I  X  W  C Pi,Pj Pk Pl    IW#  OPCD 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(0 )             |
001] MUL  R2,R2,R2      0  1  2  6  6 11 12 P3,P2,P2       ----  MUL P3  P2  P2  -    6  6  -   ---- 001 R2  P2  0 0 1  |PC   OP Pi  EFAD Ci|
002] SW   R2,0(R1)      0  1  2  4  5 11 12 ,P0(P1)<-P3    ----   SW -   P3  P1  0    -  2  -   ---- 002 -   -   1 0 1  |---- LW P2  0000  6|
003] ADDI R1,R1,4       0  1  3  4  4  5 12 P4,P1,4       ---- ADDI P4  P1  -   4    3  -  -   ---- 003 R1  P1  0 0 1  |---- LW P5  0004  8|
004] BNE  R2,R0,-5      1  2  4  5  5  6 12 ,P3,P0,-5      ----  BNE -   P3  P0  -5   -  4  -   ---- 004 -   -   0 0 1  |---- LW P8  0008 11|
005] LW   R2,0(R1)      2  3  4  5  6  8 13 P5,0(P4)       ----   LW P5  P4  -   0    5  -  -   ---- 000 R2  P3  0 0 1  +-------------------+
006] MUL  R2,R2,R2      2  3  5  8  8 13 14 P6,P5,P5       ----  MUL P6  P5  P5  -    8  8  -   ---- 001 R2  P5  0 0 1
007] SW   R2,0(R1)      2  3  5  6  7 13 14 ,P0(P4)<-P6    ----   SW -   P6  P4  0    -  5  -   ---- 002 -   -   1 0 1  +-------------------+
008] ADDI R1,R1,4       2  4  6  7  7  8 14 P7,P4,4       ---- ADDI P7  P4  -   4    6  -  -   ---- 003 R1  P4  0 0 1  |SQ(1 )             |
009] BNE  R2,R0,-5      3  4  6  7  7  8 14 ,P6,P0,-5      ----  BNE -   P6  P0  -5   -  6  -   ---- 004 -   -   0 0 1  |PC   OP Pi  EFAD Cl|
010] LW   R2,0(R1)      4  5  7  8  9 11    P8,0(P7)       ----   LW P8  P7  -   0    8  -  -   010) 000 R2  P6  0 0 1  |---- SW P0  0000 11|
011] MUL  R2,R2,R2      4  5  7 11 11       P9,P8,P8       ----  MUL P9  P8  P8  -   11 11  -   011) 001 R2  P8  0 0 0  |---- SW P0  0004 13|
012] SW   R2,0(R1)      4  6  8  9 10       ,P0(P7)<-P9    ----   SW -   P9  P7  0    -  8  -   012) 002 -   -   1 0 0  |012] SW P0  0008  .|
013] ADDI R1,R1,4       4  6  8  9  9 10    P10,P7,4       ---- ADDI P10 P7  -   4    8  -  -   013) 003 R1  P7  0 0 1  +-------------------+
014] BNE  R2,R0,-5      5  7  9 10 10 11    ,P9,P0,-5      ----  BNE -   P9  P0  -5   -  9  -   014) 004 -   -   0 0 1
------------------------------------------------- Press ENTER to continue (PC=6,IC=15,CK=14,CTOT=15,IPC=1.00)...

================================================================================================================================================
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18
                            *  *  *  *
         qi:   1  1  1  1  1  1  0  0  1  0  1  1  1  1  1  1  1  1
         vi:  00 00 00 04 00 00 08 00 00 0C 00 00 00 00 00 00 00 00
================================================================================================================================================
REG.FILE: Ri:         1        2        3        4        5        6        7        8
          Pi:        10        9        -        -        -        -        -        -
          Qi:         0        1        0        0        0        0        0        0
          Vi:  00000004 00000000 00000000 00000000 00000000 00000000 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  3  4 12  4  4 18             3                                   99                       4  1  1  0  1  4  1
BUSY SLOTS:             0  0  0  0  1  0  0 4              0                                   4                        0  0  0  0  0  0  0
STALLS:                 0  4 11  9  0  0  5 0              0                                   0                        0  0  0  1  0  0  0
================================================================================================================================================
PC   INSTRUCTION        F  D  P  I  X  W  C Pi,Pj Pk Pl    IW#  OPCD 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(0 )             |
001] MUL  R2,R2,R2      0  1  2  6  6 11 12 P3,P2,P2       ----  MUL P3  P2  P2  -    6  6  -   ---- 001 R2  P2  0 0 1  |PC   OP Pi  EFAD Ci|
002] SW   R2,0(R1)      0  1  2  4  5 11 12 ,P0(P1)<-P3    ----   SW -   P3  P1  0    -  2  -   ---- 002 -   -   1 0 1  |---- LW P2  0000  6|
003] ADDI R1,R1,4       0  1  3  4  4  5 12 P4,P1,4       ---- ADDI P4  P1  -   4    3  -  -   ---- 003 R1  P1  0 0 1  |---- LW P5  0004  8|
004] BNE  R2,R0,-5      1  2  4  5  5  6 12 ,P3,P0,-5      ----  BNE -   P3  P0  -5   -  4  -   ---- 004 -   -   0 0 1  |---- LW P8  0008 11|
005] LW   R2,0(R1)      2  3  4  5  6  8 13 P5,0(P4)       ----   LW P5  P4  -   0    5  -  -   ---- 000 R2  P3  0 0 1  +-------------------+
006] MUL  R2,R2,R2      2  3  5  8  8 13 14 P6,P5,P5       ----  MUL P6  P5  P5  -    8  8  -   ---- 001 R2  P5  0 0 1
007] SW   R2,0(R1)      2  3  5  6  7 13 14 ,P0(P4)<-P6    ----   SW -   P6  P4  0    -  5  -   ---- 002 -   -   1 0 1  +-------------------+
008] ADDI R1,R1,4       2  4  6  7  7  8 14 P7,P4,4       ---- ADDI P7  P4  -   4    6  -  -   ---- 003 R1  P4  0 0 1  |SQ(1 )             |
009] BNE  R2,R0,-5      3  4  6  7  7  8 14 ,P6,P0,-5      ----  BNE -   P6  P0  -5   -  6  -   ---- 004 -   -   0 0 1  |PC   OP Pi  EFAD Cl|
010] LW   R2,0(R1)      4  5  7  8  9 11 15 P8,0(P7)       ----   LW P8  P7  -   0    8  -  -   ---- 000 R2  P6  0 0 1  |---- SW P0  0000 11|
011] MUL  R2,R2,R2      4  5  7 11 11       P9,P8,P8       ----  MUL P9  P8  P8  -   11 11  -   011) 001 R2  P8  0 0 0  |---- SW P0  0004 13|
012] SW   R2,0(R1)      4  6  8  9 10       ,P0(P7)<-P9    ----   SW -   P9  P7  0    -  8  -   012) 002 -   -   1 0 0  |012] SW P0  0008  .|
013] ADDI R1,R1,4       4  6  8  9  9 10    P10,P7,4       ---- ADDI P10 P7  -   4    8  -  -   013) 003 R1  P7  0 0 1  +-------------------+
```

```
014] BNE  R2,R0,-5      5  7  9 10 10 11    ,P9,P0,-5      ----  BNE -   P9  P0  -5   -  9  -   014) 004 -   -   0 0 1
------------------------------------------------- Press ENTER to continue (PC=6,IC=15,CK=15,CTOT=16,IPC=0.94)...


================================================================================================================================================
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18
                                  *  *  *  *
         qi:   1  1  1  1  1  1  0  0  0  0  1  1  1  1  1  1  1  1
         vi:  00 00 00 04 00 00 08 00 00 0C 00 00 00 00 00 00 00 00
================================================================================================================================================
REG.FILE: Ri:         1        2        3        4        5        6        7        8
          Pi:        10        9        -        -        -        -        -        -
          Qi:         0        0        0        0        0        0        0        0
          Vi:  00000004 00000000 00000000 00000000 00000000 00000000 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  3  4 12  4  4 18             3                                  99                       4  1  1  0  1  4  1
BUSY SLOTS:             0  0  0  0  0  1  0 4              0                                  4                        0  0  0  0  0  0  0
STALLS:                 0  4 11  9  0  0  6 0              0                                  0                        0  0  0  1  0  0  0
================================================================================================================================================
PC   INSTRUCTION        F  D  P  I  X  W  C Pi,Pj Pk Pl    IW#  OPCD 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(0 )             |
001] MUL  R2,R2,R2      0  1  2  6  6 11 12 P3,P2,P2       ----  MUL P3  P2  P2  -    6  6  -   ---- 001 R2  P2  0 0 1  |PC   OP Pi  EFAD Ci|
002] SW   R2,0(R1)      0  1  2  4  5 11 12 ,P0(P1)<-P3    ----   SW -   P3  P1  0    -  2  -   ---- 002 -   -   1 0 1  |---- LW P2  0000  6|
003] ADDI R1,R1,4       0  1  3  4  4  5 12 P4,P1,4        ---- ADDI P4  P1  -   4    3  -  -   ---- 003 R1  P1  0 0 1  |---- LW P5  0004  8|
004] BNE  R2,R0,-5      1  2  4  5  5  6 12 ,P3,P0,-5      ----  BNE -   P3  P0  -5   -  4  -   ---- 004 -   -   0 0 1  |---- LW P8  0008 11|
005] LW   R2,0(R1)      2  3  4  5  6  8 13 P5,0(P4)       ----   LW P5  P4  -   0    5  -  -   ---- 000 R2  P3  0 0 1  +-------------------+
006] MUL  R2,R2,R2      2  3  5  8  8 13 14 P6,P5,P5       ----  MUL P6  P5  P5  -    8  8  -   ---- 001 R2  P5  0 0 1
007] SW   R2,0(R1)      2  3  5  6  7 13 14 ,P0(P4)<-P6    ----   SW -   P6  P4  0    -  5  -   ---- 002 -   -   1 0 1  +-------------------+
008] ADDI R1,R1,4       2  4  6  7  7  8 14 P7,P4,4        ---- ADDI P7  P4  -   4    6  -  -   ---- 003 R1  P4  0 0 1  |SQ(0 )             |
009] BNE  R2,R0,-5      3  4  6  7  7  8 14 ,P6,P0,-5      ----  BNE -   P6  P0  -5   -  6  -   ---- 004 -   -   0 0 1  |PC   OP Pi  EFAD Cl|
010] LW   R2,0(R1)      4  5  7  8  9 11 15 P8,0(P7)       ----   LW P8  P7  -   0    8  -  -   ---- 000 R2  P6  0 0 1  |---- SW P0  0000 11|
011] MUL  R2,R2,R2      4  5  7 11 11 16    P9,P8,P8       ----  MUL P9  P8  P8  -   11 11  -   011) 001 R2  P8  0 0 1  |---- SW P0  0004 13|
012] SW   R2,0(R1)      4  6  8  9 10 16    ,P0(P7)<-P9    ----   SW -   P9  P7  0    -  8  -   012) 002 -   -   1 0 1  |---- SW P0  0008 16|
013] ADDI R1,R1,4       4  6  8  9  9 10    P10,P7,4       ---- ADDI P10 P7  -   4    8  -  -   013) 003 R1  P7  0 0 1  +-------------------+
014] BNE  R2,R0,-5      5  7  9 10 10 11    ,P9,P0,-5      ----  BNE -   P9  P0  -5   -  9  -   014) 004 -   -   0 0 1
------------------------------------------- Press ENTER to continue (PC=6,IC=15,CK=16,CTOT=17,IPC=0.88)...
@016 stall due to NO SLOTS when trying to move instuction SW/007 from stage W to stage C.

================================================================================================================================================
PHYSICAL REGS:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18
                                     *  *
         qi:   1  1  1  1  1  1  1  1  0  0  1  1  1  1  1  1  1  1
         vi:  00 00 00 04 00 00 08 00 00 0C 00 00 00 00 00 00 00 00
================================================================================================================================================
REG.FILE: Ri:         1        2        3        4        5        6        7        8
          Pi:        10        9        -        -        -        -        -        -
          Qi:         0        0        0        0        0        0        0        0
          Vi:  00000008 00000000 00000000 00000000 00000000 00000000 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  3  4 12  4  4 18             3                                  99                       4  1  1  0  1  4  1
BUSY SLOTS:             0  0  0  0  0  1  0 2              0                                  0                        0  0  0  0  0  0  0
STALLS:                 0  4 11  9  0  0  6 0              0                                  0                        0  0  0  1  0  0  0
================================================================================================================================================
PC   INSTRUCTION        F  D  P  I  X  W  C Pi,Pj Pk Pl    IW#  OPCD 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(0 )             |
001] MUL  R2,R2,R2      0  1  2  6  6 11 12 P3,P2,P2       ----  MUL P3  P2  P2  -    6  6  -   ---- 001 R2  P2  0 0 1  |PC   OP Pi  EFAD Ci|
002] SW   R2,0(R1)      0  1  2  4  5 11 12 ,P0(P1)<-P3    ----   SW -   P3  P1  0    -  2  -   ---- 002 -   -   1 0 1  |---- LW P2  0000  6|
003] ADDI R1,R1,4       0  1  3  4  4  5 12 P4,P1,4        ---- ADDI P4  P1  -   4    3  -  -   ---- 003 R1  P1  0 0 1  |---- LW P5  0004  8|
004] BNE  R2,R0,-5      1  2  4  5  5  6 12 ,P3,P0,-5      ----  BNE -   P3  P0  -5   -  4  -   ---- 004 -   -   0 0 1  |---- LW P8  0008 11|
005] LW   R2,0(R1)      2  3  4  5  6  8 13 P5,0(P4)       ----   LW P5  P4  -   0    5  -  -   ---- 000 R2  P3  0 0 1  +-------------------+
006] MUL  R2,R2,R2      2  3  5  8  8 13 14 P6,P5,P5       ----  MUL P6  P5  P5  -    8  8  -   ---- 001 R2  P5  0 0 1
007] SW   R2,0(R1)      2  3  5  6  7 13 14 ,P0(P4)<-P6    ----   SW -   P6  P4  0    -  5  -   ---- 002 -   -   1 0 1  +-------------------+
008] ADDI R1,R1,4       2  4  6  7  7  8 14 P7,P4,4        ---- ADDI P7  P4  -   4    6  -  -   ---- 003 R1  P4  0 0 1  |SQ(0 )             |
009] BNE  R2,R0,-5      3  4  6  7  7  8 14 ,P6,P0,-5      ----  BNE -   P6  P0  -5   -  6  -   ---- 004 -   -   0 0 1  |PC   OP Pi  EFAD Cl|
010] LW   R2,0(R1)      4  5  7  8  9 11 15 P8,0(P7)       ----   LW P8  P7  -   0    8  -  -   ---- 000 R2  P6  0 0 1  |---- SW P0  0000 11|
011] MUL  R2,R2,R2      4  5  7 11 11 16 17 P9,P8,P8       ----  MUL P9  P8  P8  -   11 11  -   ---- 001 R2  P8  0 0 1  |---- SW P0  0004 13|
012] SW   R2,0(R1)      4  6  8  9 10 16 17 ,P0(P7)<-P9    ----   SW -   P9  P7  0    -  8  -   ---- 002 -   -   1 0 1  |---- SW P0  0008 16|
013] ADDI R1,R1,4       4  6  8  9  9 10 17 P10,P7,4       ---- ADDI P10 P7  -   4    8  -  -   ---- 003 R1  P7  0 0 1  +-------------------+
014] BNE  R2,R0,-5      5  7  9 10 10 11 17 ,P9,P0,-5      ----  BNE -   P9  P0  -5   -  9  -   ---- 004 -   -   0 0 1
```

```
------------------------------------------------- Press ENTER to continue (PC=6,IC=15,CK=17,CTOT=18,IPC=0.83)...

Program 'prog151106' FINISHED
------------------------------------------------------------
PC=6,IC=15,CK=18,IPC=0.83
Goodbye.
```