|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 1 | I-E-RS | ori | D | RS | ori $4,0xffff  jr $4 |

ori $4 $0 0x3010

jr $4

addu $8 $5 $6

subu $9 $5 $6

ori $10 $5 0x2345

addu $8 $5 $6

subu $9 $5 $6

ori $10 $5 0x2345

225@00003000: $ 4 <= 00003010

375@00003008: $ 8 <= 00000000

425@00003010: $10 <= 00002345

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 2 | LD-M-RS | lw | D | RS | lw $4,0($5)  nop  jr $4 |

ori $4 $0 0x3020

ori $5 $0 0x0088

sw $4 0($5)

lw $6 0($5)

nop

jr $6

ori $8 $0 0x1234

ori $9 $0 0x1234

ori $10 $0 0x1234

ori $11 $0 0x1234

ori $12 $0 0x1234

225@00003000: $ 4 <= 00003020

275@00003004: $ 5 <= 00000088

275@00003008: \*00000088 <= 00003020

375@0000300c: $ 6 <= 00003020

575@00003018: $ 8 <= 00001234

625@00003020: $10 <= 00001234

675@00003024: $11 <= 00001234

725@00003028: $12 <= 00001234

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 3LD型 | LD-E-RS | lw | D | RS | lw $4,0($5)  lw $3,4($4) |

ori $4 $0 0x1234

ori $5 $0 0x0088

sw $5 0($5)

lw $6 0($5)

lw $7 0($6)

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 00000088

275@00003008: \*00000088 <= 00000088

375@0000300c: $ 6 <= 00000088

475@00003010: $ 7 <= 00000088

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 4ST型 | LD-E-RS | lw | D | RS | lw $4,0($5)  sw $3,4($4) |

ori $5 $0 0x0088

ori $6 $0 0x1234

sw $5 0($5)

lw $4 0($5)

sw $6 0($4)

225@00003000: $ 5 <= 00000088

275@00003004: $ 6 <= 00001234

275@00003008: \*00000088 <= 00000088

375@0000300c: $ 4 <= 00000088

425@00003010: \*00000088 <= 00001234

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 5B型 | R-E-RS | addu | D | RS | addu $4,$4,$5  beq $4,$5,loop |

ori $5 $0 0x1234

addu $4 $4 $5

beq $4 $5 label

ori $10 $0 0x1234

ori $11 $0 0x2345

ori $12 $0 0x3456

label:

ori $10 $0 0xabcd

ori $11 $0 0xcdef

ori $12 $0 0xffff

225@00003000: $ 5 <= 00001234

275@00003004: $ 4 <= 00001234

425@0000300c: $10 <= 00001234

475@00003018: $10 <= 0000abcd

525@0000301c: $11 <= 0000cdef

575@00003020: $12 <= 0000ffff

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 6 | I-E-RS | ori | D | RS | ori $4,0xffff  beq $4,$5,loop |

ori $4 $0 0x1234

ori $5 $0 0x1234

beq $4 $5 label

ori $4 $0 0x1234

ori $5 $0 0x1234

ori $4 $0 0x1234

label:

ori $6 $0 0x1234

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 00001234

425@0000300c: $ 4 <= 00001234

475@00003018: $ 6 <= 00001234

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 7 | LD-E-RS | lw | D | RS | lw $4,0($5)  beq $4,$5,loop |

ori $4 $0 0x1234

ori $5 $0 0x0088

sw $4 0($5)

lw $7 0($5)

beq $7 $4 label

ori $8 $0 0x1234

ori $9 $0 0x1234

ori $10 $0 0x1234

label:

ori $6 $0 0x1234

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 00000088

275@00003008: \*00000088 <= 00001234

375@0000300c: $ 7 <= 00001234

575@00003014: $ 8 <= 00001234

625@00003020: $ 6 <= 00001234

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 8 | LD-M-RS | lw | D | RS | lw $4,0($5)  nop  beq $4,$5,loop |

ori $4 $0 0x1234

ori $5 $0 0x0088

sw $4 0($5)

lw $7 0($5)

nop

beq $7 $4 label

ori $8 $0 0x1234

ori $9 $0 0x1234

ori $10 $0 0x1234

label:

ori $6 $0 0x1234

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 00000088

275@00003008: \*00000088 <= 00001234

375@0000300c: $ 7 <= 00001234

575@00003018: $ 8 <= 00001234

625@00003024: $ 6 <= 00001234

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 9 | R-E-RT | addu | D | RT | addu $4,$4,$5  beq $5,$4,loop |

ori $4 $0 0x1234

ori $5 $0 0x0088

sw $4 0($5)

lw $7 0($5)

addu $8 $7 $0

beq $8 $4 label

ori $8 $0 0xaaaa

ori $9 $0 0x1234

ori $10 $0 0x1234

label:

ori $6 $0 0x1234

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 00000088

275@00003008: \*00000088 <= 00001234

375@0000300c: $ 7 <= 00001234

475@00003010: $ 8 <= 00001234

625@00003018: $ 8 <= 0000aaaa

675@00003024: $ 6 <= 00001234

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 10R型  (以addu为例) | R-W-RS | addu | D | RS | addu $4,$4,$5  nop  nop  addu $4,$4,$5 |

ori $4 $0 0x1234

ori $5 $0 0xabcd

addu $4 $4 $5

nop

nop

addu $4 $4 $5

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 0000abcd

325@00003008: $ 4 <= 0000be01

475@00003014: $ 4 <= 000169ce

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 11 | I-W-RS | ori | D | RS | ori $4,$5,0xffff  nop  nop  addu $4,$4,$5 |

ori $4 $0 0x1234

ori $5 $0 0xabcd

nop

nop

addu $4 $4 $5

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 0000abcd

425@00003010: $ 4 <= 0000be01

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 12 | LD-W-RS | lw | D | RS | lw $4,0($5)  nop  nop  addu $4,$4,$5 |

ori $4 $0 0x1234

ori $5 $0 0xabcd

sw $5 0($0) 问题同3

lw $8 0($0)

nop

nop

addu $4 $8 $5

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 0000abcd

275@00003008: \*00000000 <= 0000abcd

375@0000300c: $ 8 <= 0000abcd

525@00003018: $ 4 <= 0001579a

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 13 | JAL-W-RS | jal | D | RS | jal loop  nop  nop  addu $1,$31,$1 |

jal loop

ori $4 $0 0x1234

ori $5 $0 0x1234

loop:

addu $1 $31 $4

ori $6 $0 0x1234

ori $7 $0 0x1234

225@00003000: $31 <= 00003008

275@00003004: $ 4 <= 00001234

325@0000300c: $ 1 <= 0000423c

375@00003010: $ 6 <= 00001234

425@00003014: $ 7 <= 00001234

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 14 | R-W-RT | addu | D | RT | addu $4,$4,$5  nop  nop  addu $4, $5,$4 |

ori $4 $0 0x1234

ori $5 $0 0xabcd

addu $4 $4 $5

nop

nop

addu $4 $5 $4

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 0000abcd

325@00003008: $ 4 <= 0000be01

475@00003014: $ 4 <= 000169ce

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 15 | LD-W-RT | lw | D | RT | lw $4,0($5)  nop  nop  addu $4,$5,$4 |

ori $4 $0 0x1234

ori $5 $0 0x0088

sw $4 0($5)

lw $4 0($5)

nop

nop

addu $4 $5 $4

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 00000088

275@00003008: \*00000088 <= 00001234

375@0000300c: $ 4 <= 00001234

525@00003018: $ 4 <= 000012bc

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 16 | JAL-W-RT | jal | D | RT | jal loop  nop  nop  addu $1,$1,$31 |

jal loop

ori $4 $0 0x1234

ori $5 $0 0x1234

loop:

addu $1 $4 $31

ori $6 $0 0x1234

ori $7 $0 0x1234

225@00003000: $31 <= 00003008

275@00003004: $ 4 <= 00001234

325@0000300c: $ 1 <= 0000423c

375@00003010: $ 6 <= 00001234

425@00003014: $ 7 <= 00001234

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 17 | JAL-W-RS | jal | E | RS | jal loop  nop  addu $1,$31,$1  nop |

jal loop

ori $4 $0 0x1234

loop:

addu $1 $4 $31

ori $6 $0 0x1234

ori $7 $0 0x1234

225@00003000: $31 <= 00003008

275@00003004: $ 4 <= 00001234

325@00003008: $ 1 <= 0000423c

375@0000300c: $ 6 <= 00001234

425@00003010: $ 7 <= 00001234

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 18 | JAL-M-RS | jal | E | RS | jal loop  addu $1,$31,$1  nop |

jal loop

loop:

addu $1 $4 $31

ori $6 $0 0x1234

ori $7 $0 0x1234

225@00003000: $31 <= 00003008

275@00003004: $ 1 <= 00003008 $ra存储，STALL一个周期

325@00003004: $ 1 <= 00003008

375@00003008: $ 6 <= 00001234

425@0000300c: $ 7 <= 00001234

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 19 | R-W-RS | addu | E | RS | addu $4,$4,$5  nop  addu $4,$4,$5 |

ori $4 $0 0x1234

ori $5 $0 0xabcd

addu $4 $4 $5

nop

addu $4 $5 $4

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 0000abcd

325@00003008: $ 4 <= 0000be01

425@00003010: $ 4 <= 000169ce

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 20 | I-W-RS | ori | E | RS | ori $4,$5,0xffff  nop  addu $4,$4,$5  nop |

ori $4 $0 0x1234

ori $5 $0 0xabcd

ori $4 $5 0xffff

nop

addu $4 $5 $4

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 0000abcd

325@00003008: $ 4 <= 0000ffff

425@00003010: $ 4 <= 0001abcc

ori $4 $0 0x1234

ori $5 $0 0x0088

sw $4 0($5)

lw $4 0($5)

nop

addu $4 $5 $4

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 00000088

275@00003008: \*00000088 <= 00001234

375@0000300c: $ 4 <= 00001234

475@00003014: $ 4 <= 000012bc

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 21 | R-M-RS | addu | E | RS | addu $4,$4,$5  addu $4,$4,$5  nop |

ori $4 $0 0x1234

ori $5 $0 0x1234

addu $6 $5 $5

addu $7 $5 $6

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 00001234

325@00003008: $ 6 <= 00002468

375@0000300c: $ 7 <= 0000369c

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 22 | I-M-RS | ori | E | RS | ori $4,$5,0xffff  addu $4,$4,$5  nop |

ori $4 $0 0x1234

ori $5 $0 0x0088

sw $4 0($5)

lw $4 0($5)

nop

addu $4 $5 $4

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 00000088

275@00003008: \*00000088 <= 00001234

375@0000300c: $ 4 <= 00001234

475@00003014: $ 4 <= 000012bc

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | JAL-W-RT | jal | E | RT | jal loop  nop  addu $1,$1,$31  nop |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 23 | JAL-M-RT | jal | E | RT | jal loop  addu $1,$1,$31  nop |

jal loop

loop:

ori $4 $31 0x1111

ori $6 $0 0x1234

ori $7 $0 0x1234

225@00003000: $31 <= 00003008

275@00003004: $ 4 <= 00003119 $31转发回写问题

325@00003004: $ 4 <= 00003119

375@00003008: $ 6 <= 00001234

425@0000300c: $ 7 <= 00001234

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 24 | I-M-RT | ori | E | RT | ori $4,$5,0xffff  addu $4,$5,$4  nop |

ori $4 $0 0x1234

ori $5 $0 0x1234

addu $6 $5 $5

addu $7 $5 $6

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 00001234

325@00003008: $ 6 <= 00002468

375@0000300c: $ 7 <= 0000369c

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 25I型  (以ori为例) | R-W-RS | addu | D | RS | addu $4,$4,$5  nop  nop  ori $4,$4,0xffff |

ori $4 $0 0x1234

ori $5 $0 0xaaaa

addu $6 $5 $4

nop

nop

ori $6 $6 0xffff

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 0000aaaa

325@00003008: $ 6 <= 0000bcde

475@00003014: $ 6 <= 0000ffff

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 26 | R-W-RS | addu | E | RS | addu $4,$4,$5  nop  ori $4,$4,0xffff  nop |

ori $4 $0 0x1234

ori $5 $0 0xaaaa

addu $6 $5 $4

nop

ori $6 $6 0xffff

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 0000aaaa

325@00003008: $ 6 <= 0000bcde

425@00003010: $ 6 <= 0000ffff

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 27 | R-M-RS | addu | E | RS | addu $4,$4,$5  ori $4,$4,0xffff  nop |

ori $4 $0 0x1234

ori $5 $0 0xaaaa

addu $6 $5 $4

ori $6 $6 0xffff

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 0000aaaa

325@00003008: $ 6 <= 0000bcde

375@0000300c: $ 6 <= 0000ffff

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 28 | I-W-RS | ori | D | RS | ori $4,$5,0xffff  nop  nop  ori $4,$4,0x0000 |

ori $4 $0 0x1234

ori $5 $4 0xabcd

nop

nop

ori $6 $5 0xcdef

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 0000bbfd

425@00003010: $ 6 <= 0000ffff

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 29 | I-W-RS | ori | E | RS | ori $4,$5,0xffff  nop  ori $4,$4,0x0f0f  nop |

ori $4 $0 0x1234

ori $5 $4 0xabcd

nop

ori $6 $5 0xcdef

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 0000bbfd

375@0000300c: $ 6 <= 0000ffff

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 30 | I-M-RS | ori | E | RS | ori $4,$5,0xffff  ori $4,$4,0xf0f0  nop |

ori $4 $0 0x1234

ori $5 $4 0xabcd

ori $6 $5 0xcdef

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 0000bbfd

325@00003008: $ 6 <= 0000ffff

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 31 | LD-W-RS | lw | D | RS | lw $4,0($5)  nop  nop  ori $4,$4,0xffff |

ori $4 $0 0x1234

ori $5 $0 0x0088

sw $4 0($5)

lw $6 0($5)

nop

nop

ori $9 $6 0xaaaa

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 00000088

275@00003008: \*00000088 <= 00001234

375@0000300c: $ 6 <= 00001234

525@00003018: $ 9 <= 0000babe

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 32 | LD-W-RS | lw | E | RS | lw $4,0($5)  nop  ori $4,$4,0xffff  nop |

ori $4 $0 0x1234

ori $5 $0 0x0088

sw $4 0($5)

lw $6 0($5)

nop

ori $9 $6 0xaaaa

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 00000088

275@00003008: \*00000088 <= 00001234

375@0000300c: $ 6 <= 00001234

475@00003014: $ 9 <= 0000babe

ori $4 $0 0x1234

ori $5 $0 0x0088

sw $4 0($5)

lw $6 0($5)

ori $9 $6 0xaaaa

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 00000088

275@00003008: \*00000088 <= 00001234

375@0000300c: $ 6 <= 00001234

475@00003010: $ 9 <= 0000babe

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 33 | JAL-W-RS | jal | E | RS | jal loop  nop  ori $1,$31,0xffff  nop |

jal loop

nop

loop:

ori $4 $31 0x1234

addu $5 $4 $4

225@00003000: $31 <= 00003008

325@00003008: $ 4 <= 0000323c

375@0000300c: $ 5 <= 00006478

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 34 | JAL-M-RS | jal | E | RS | jal loop  ori $1,$31,0xfff0  nop |

jal loop

loop:

ori $4 $31 0x1234

addu $5 $4 $4

225@00003000: $31 <= 00003008

275@00003004: $ 4 <= 0000323c

325@00003004: $ 4 <= 0000323c

375@00003008: $ 5 <= 00006478

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| LD型 | R-W-RS | addu | D | RS | addu $4,$4,$5  nop  nop  lw $5,0($4) |

ori $4 $0 0x0088

ori $5 $0 0x0004

addu $6 $4 $5

sw $4 4($6)

addu $7 $6 $5

nop

nop

lw $8 0($7)

225@00003000: $ 4 <= 00000088

275@00003004: $ 5 <= 00000004

325@00003008: $ 6 <= 0000008c

325@0000300c: \*00000090 <= 00000088

425@00003010: $ 7 <= 00000090

575@0000301c: $ 8 <= 00000088

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | R-W-RS | addu | E | RS | addu $4,$4,$5  nop  lw $5,0($4)  nop |

ori $4 $0 0x0088

ori $5 $0 0x0004

addu $6 $4 $5

sw $4 4($6)

addu $7 $6 $5

nop

lw $8 0($7)

225@00003000: $ 4 <= 00000088

275@00003004: $ 5 <= 00000004

325@00003008: $ 6 <= 0000008c

325@0000300c: \*00000090 <= 00000088

425@00003010: $ 7 <= 00000090

525@00003018: $ 8 <= 00000088

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | R-M-RS | addu | E | RS | addu $4,$4,$5  lw $5,0($4)  nop |

ori $4 $0 0x0088

ori $5 $0 0x0004

addu $6 $4 $5

sw $4 4($6)

addu $7 $6 $5

lw $8 0($7)

225@00003000: $ 4 <= 00000088

275@00003004: $ 5 <= 00000004

325@00003008: $ 6 <= 0000008c

325@0000300c: \*00000090 <= 00000088

425@00003010: $ 7 <= 00000090

475@00003014: $ 8 <= 00000088

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | I-W-RS | ori | D | RS | ori $4,$5,0xffff  nop  nop  lw $5,0($4) |

ori $4 $0 0x0088

ori $5 $0 0x0004

ori $6 $4 0x0004

sw $5 0($6)

ori $7 $4 0x0004

nop

nop

lw $8 0($7)

225@00003000: $ 4 <= 00000088

275@00003004: $ 5 <= 00000004

325@00003008: $ 6 <= 0000008c

325@0000300c: \*0000008c <= 00000004

425@00003010: $ 7 <= 0000008c

575@0000301c: $ 8 <= 00000004

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | I-W-RS | ori | E | RS | ori $4,$5,0xffff  nop  lw $5,0($4)  nop |

ori $4 $0 0x0088

ori $5 $0 0x0004

ori $6 $4 0x0004

sw $5 0($6)

ori $7 $4 0x0004

nop

lw $8 0($7)

225@00003000: $ 4 <= 00000088

275@00003004: $ 5 <= 00000004

325@00003008: $ 6 <= 0000008c

325@0000300c: \*0000008c <= 00000004

425@00003010: $ 7 <= 0000008c

525@00003018: $ 8 <= 00000004

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | I-M-RS | ori | E | RS | ori $4,$5,0xffff  lw $5,0($4)  nop |

ori $4 $0 0x0088

ori $5 $0 0x0004

ori $6 $4 0x0004

sw $5 0($6)

ori $7 $4 0x0004

lw $8 0($7)

225@00003000: $ 4 <= 00000088

275@00003004: $ 5 <= 00000004

325@00003008: $ 6 <= 0000008c

325@0000300c: \*0000008c <= 00000004

425@00003010: $ 7 <= 0000008c

475@00003014: $ 8 <= 00000004

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | LD-W-RS | lw | D | RS | lw $4,0($5)  nop  nop  lw $5,0($4) |

ori $5 $0 0x010c

ori $6 $0 0x0088

sw $6 0($6)

sw $6 0($5)

lw $4 0($5)

nop

nop

lw $7 0($4)

225@00003000: $ 5 <= 0000010c

275@00003004: $ 6 <= 00000088

275@00003008: \*00000088 <= 00000088

325@0000300c: \*0000010c <= 00000088

425@00003010: $ 4 <= 00000088

575@0000301c: $ 7 <= 00000088

ori $5 $0 0x010c

ori $6 $0 0x0088

sw $6 0($6)

sw $6 0($5)

lw $4 0($5)

nop

lw $7 0($4)

225@00003000: $ 5 <= 0000010c

275@00003004: $ 6 <= 00000088

275@00003008: \*00000088 <= 00000088

325@0000300c: \*0000010c <= 00000088

425@00003010: $ 4 <= 00000088

575@0000301c: $ 7 <= 00000088

ori $5 $0 0x010c

ori $6 $0 0x0088

sw $6 0($6)

sw $6 0($5)

lw $4 0($5)

lw $7 0($4)

225@00003000: $ 5 <= 0000010c

275@00003004: $ 6 <= 00000088

275@00003008: \*00000088 <= 00000088

325@0000300c: \*0000010c <= 00000088

425@00003010: $ 4 <= 00000088

525@00003014: $ 7 <= 00000088

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **JAL-W-RS** | **jal** | **D** | **RS** | **jal loop**  **nop**  **nop**  **lw $5,0($31)** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ST型 | R-W-RS | addu | D | RS | addu $4,$4,$5  nop  nop  sw $5,0($4) |

ori $4 $0 0x000c

ori $5 $0 0x0088

addu $6 $4 $5

nop

nop

sw $5,0($6)

225@00003000: $ 4 <= 0000000c

275@00003004: $ 5 <= 00000088

325@00003008: $ 6 <= 00000094

425@00003014: \*00000094 <= 00000088

ori $4 $0 0x000c

ori $5 $0 0x0088

addu $6 $4 $5

nop

sw $5,0($6)

225@00003000: $ 4 <= 0000000c

275@00003004: $ 5 <= 00000088

325@00003008: $ 6 <= 00000094

375@00003010: \*00000094 <= 00000088

ori $4 $0 0x000c

ori $5 $0 0x0088

addu $6 $4 $5

sw $5,0($6)

225@00003000: $ 4 <= 0000000c

275@00003004: $ 5 <= 00000088

325@00003008: $ 6 <= 00000094

325@0000300c: \*00000094 <= 00000088

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | I-W-RS | ori | D | RS | ori $4,$5,0xffff  nop  nop  sw $5,0($4) |

ori $4 $0 0x0088

ori $5 $0 0x0004

ori $6 $4 0x0004

nop

nop

sw $5 0($6)

225@00003000: $ 4 <= 00000088

275@00003004: $ 5 <= 00000004

325@00003008: $ 6 <= 0000008c

425@00003014: \*0000008c <= 00000004

ori $4 $0 0x0088

ori $5 $0 0x0004

ori $6 $4 0x0004

nop

sw $5 0($6)

225@00003000: $ 4 <= 00000088

275@00003004: $ 5 <= 00000004

325@00003008: $ 6 <= 0000008c

375@00003010: \*0000008c <= 00000004

ori $4 $0 0x0088

ori $5 $0 0x0004

ori $6 $4 0x0004

sw $5 0($6)

225@00003000: $ 4 <= 00000088

275@00003004: $ 5 <= 00000004

325@00003008: $ 6 <= 0000008c

325@0000300c: \*0000008c <= 00000004

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | LD-W-RS | lw | D | RS | lw $4,0($5)  nop  nop  sw $5,0($4) |

ori $5 $0 0x0088

ori $6 $0 0x1234

sw $5 0($5)

lw $4 0($5)

nop

nop

sw $6 0($4)

225@00003000: $ 5 <= 00000088

275@00003004: $ 6 <= 00001234

275@00003008: \*00000088 <= 00000088

375@0000300c: $ 4 <= 00000088

475@00003018: \*00000088 <= 00001234

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | LD-W-RS | lw | E | RS | lw $4,0($5)  nop  sw $5,0($4)  nop |

ori $5 $0 0x0088

ori $6 $0 0x1234

sw $5 0($5)

lw $4 0($5)

nop

sw $6 0($4)

225@00003000: $ 5 <= 00000088

275@00003004: $ 6 <= 00001234

275@00003008: \*00000088 <= 00000088

375@0000300c: $ 4 <= 00000088

425@00003014: \*00000088 <= 00001234

ori $5 $0 0x0088

ori $6 $0 0x1234

sw $5 0($5)

lw $4 0($5)

sw $6 0($4)

225@00003000: $ 5 <= 00000088

275@00003004: $ 6 <= 00001234

275@00003008: \*00000088 <= 00000088

375@0000300c: $ 4 <= 00000088

425@00003010: \*00000088 <= 00001234

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **JAL-W-RS** | **jal** | **D** | **RS** | **jal loop**  **nop**  **nop**  **sw $5,0($31)** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **JAL-M-RS** | **jal** | **E** | **RS** | **jal loop**  **sw $5,0($31)**  **nop** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | I-W-RT | ori | D | RT | ori $4,$5,0xffff  nop  nop  sw $4,0($5) |

ori $5 $0 0x0008

ori $8 $5 0x00c0

nop

nop

sw $8 0($5)

225@00003000: $ 5 <= 00000008

275@00003004: $ 8 <= 000000c8

375@00003010: \*00000008 <= 000000c8

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | LD-W-RT | lw | D | RT | lw $4,0($5)  nop  nop  sw $4,0($6) |

ori $5 $0 0x0008

sw $5 0($5)

lw $8 0($5)

nop

nop

sw $8 4($5)

225@00003000: $ 5 <= 00000008

225@00003004: \*00000008 <= 00000008

325@00003008: $ 8 <= 00000008

425@00003014: \*0000000c <= 00000008

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | JAL-W-RT | jal | D | RT | jal loop  nop  nop  sw $31,0($5) |

jal label

ori $8 $0 0x1234

label:

nop

sw $31 4($5)

225@00003000: $31 <= 00003008

275@00003004: $ 8 <= 00001234

325@0000300c: \*00000004 <= 00003008

jal label

ori $8 $0 0x1234

label:

sw $31 4($5)

225@00003000: $31 <= 00003008

275@00003004: $ 8 <= 00001234

275@00003008: \*00000004 <= 00003008

jal label

label:

sw $31 4($5)

225@00003000: $31 <= 00003008

225@00003004: \*00000004 <= 00003008

275@00003004: \*00000004 <= 00003008

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| JR | R-W-RS | addu | D | RS | addu $4,$4,$5  nop  nop  jr $4 |

ori $4 $0 0x0008

ori $5 $0 0x3004

addu $6 $4 $5

addu $7 $7 $5

nop

jr $6

nop

225@00003000: $ 4 <= 00000008

275@00003004: $ 5 <= 00003004

325@00003008: $ 6 <= 0000300c

375@0000300c: $ 7 <= 00003004

575@0000300c: $ 7 <= 00006008

775@0000300c: $ 7 <= 0000900c

975@0000300c: $ 7 <= 0000c010

ori $4 $0 0x0008

ori $5 $0 0x3004

addu $6 $4 $5

addu $7 $7 $5

jr $6

nop

225@00003000: $ 4 <= 00000008

275@00003004: $ 5 <= 00003004

325@00003008: $ 6 <= 0000300c

375@0000300c: $ 7 <= 00003004

525@0000300c: $ 7 <= 00006008

675@0000300c: $ 7 <= 0000900c

825@0000300c: $ 7 <= 0000c010

975@0000300c: $ 7 <= 0000f014

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | I-W-RS | ori | D | RS | ori $4,$5,0xffff  nop  nop  jr $4 |

ori $4 $0 0x0008

ori $5 $0 0x3004

addu $6 $4 $5

nop

jr $5

nop

225@00003000: $ 4 <= 00000008

275@00003004: $ 5 <= 00003004

325@00003008: $ 6 <= 0000300c

525@00003004: $ 5 <= 00003004

575@00003008: $ 6 <= 0000300c

775@00003004: $ 5 <= 00003004

825@00003008: $ 6 <= 0000300c

ori $4 $0 0x0008

ori $5 $0 0x3004

addu $6 $4 $5

jr $5

nop

225@00003000: $ 4 <= 00000008

275@00003004: $ 5 <= 00003004

325@00003008: $ 6 <= 0000300c

475@00003004: $ 5 <= 00003004

525@00003008: $ 6 <= 0000300c

675@00003004: $ 5 <= 00003004

725@00003008: $ 6 <= 0000300c

875@00003004: $ 5 <= 00003004

925@00003008: $ 6 <= 0000300c

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | JAL-W-RS | jal | D | RS | jal loop  nop  nop  jr $31 |

jal label

ori $5 $0 0x1234

ori $6 $0 0x2345

label:

jr $ra

nop

225@00003000: $31 <= 00003008

275@00003004: $ 5 <= 00001234

425@00003008: $ 6 <= 00002345

575@00003008: $ 6 <= 00002345

725@00003008: $ 6 <= 00002345

875@00003008: $ 6 <= 00002345

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **JAL-M-RS** | **jal** | **D** | **RS** | **jal loop**  **nop**  **jr $31** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **JAL-E-RS** | **jal** | **D** | **RS** | **jal loop**  **jr $31** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| B型 | R-W-RS | addu | D | RS | addu $4,$4,$5  nop  nop  beq $4,$3,loop |

ori $4 $0 0x1234

addu $5 $4 $0

nop

nop

beq $5 $4 label

ori $6 $5 0x2356

ori $7 $5 0x2356

label:

ori $8 $5 0x2356

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 00001234

475@00003014: $ 6 <= 00003376

525@0000301c: $ 8 <= 00003376

ori $4 $0 0x1234

addu $5 $4 $0

nop

beq $5 $4 label

ori $6 $5 0x2356

ori $7 $5 0x2356

label:

ori $8 $5 0x2356

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 00001234

425@00003010: $ 6 <= 00003376

475@00003018: $ 8 <= 00003376

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | I-W-RT | ori | D | RT | ori $4,$5,0xffff  nop  nop  beq $3,$4,loop |

ori $4 $0 0x1234

ori $5 $4 0

nop

nop

beq $5 $4 label

ori $6 $5 0x2356

ori $7 $5 0x2356

label:

ori $8 $5 0x2356

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 00001234

475@00003014: $ 6 <= 00003376

525@0000301c: $ 8 <= 00003376

ori $4 $0 0x1234

ori $5 $4 0

nop

beq $5 $4 label

ori $6 $5 0x2356

ori $7 $5 0x2356

label:

ori $8 $5 0x2356

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 00001234

425@00003010: $ 6 <= 00003376

475@00003018: $ 8 <= 00003376

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | LD-W-RT | lw | D | RT | lw $4,0($5)  nop  nop  beq $3,$4,loop |

ori $4 $0 0x1234

ori $5 $0 0x0088

sw $4 0($5)

lw $7 0($5)

addu $8 $7 $0

nop

beq $8 $4 label

ori $8 $0 0xaaaa

ori $9 $0 0x1234

ori $10 $0 0x1234

label:

ori $6 $0 0x1234

225@00003000: $ 4 <= 00001234

275@00003004: $ 5 <= 00000088

275@00003008: \*00000088 <= 00001234

375@0000300c: $ 7 <= 00001234

475@00003010: $ 8 <= 00001234

625@0000301c: $ 8 <= 0000aaaa

675@00003028: $ 6 <= 00001234

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | JAL-W-RT | jal | D | RT | jal loop  nop  nop  beq $3,$31,loop |

jal label

label:

ori $5 $0 0x3008

label2:

ori $6 $0 0x1234

beq $5 $ra label2

ori $9 $0 0x1234

225@00003000: $31 <= 00003008

275@00003004: $ 5 <= 00003008

325@00003004: $ 5 <= 00003008

375@00003008: $ 6 <= 00001234

475@00003010: $ 9 <= 00001234

525@00003008: $ 6 <= 00001234

625@00003010: $ 9 <= 00001234

675@00003008: $ 6 <= 00001234

775@00003010: $ 9 <= 00001234

825@00003008: $ 6 <= 00001234

925@00003010: $ 9 <= 00001234

975@00003008: $ 6 <= 00001234

ori $5 $0 0x300c

jal label

label:

ori $6 $0 0x1234

beq $5 $ra label

ori $9 $0 0x1234

225@00003000: $ 5 <= 0000300c

275@00003004: $31 <= 0000300c

325@00003008: $ 6 <= 00001234

375@00003008: $ 6 <= 00001234

475@00003010: $ 9 <= 00001234

525@00003008: $ 6 <= 00001234

625@00003010: $ 9 <= 00001234

675@00003008: $ 6 <= 00001234

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **JAL-E-RT** | **jal** | **D** | **RT** | **jal loop**  **beq $3,$31,loop** |