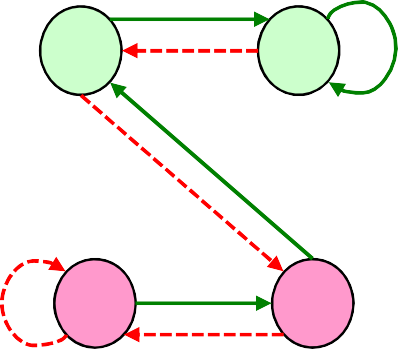
**Problem 1.**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Instruction | Fet | Dec | Iss | RS | LSQ | ROB | Exe | CDB | Com |  |
| 1 | addi **v0**, a2, 0x3 | 1 | 2 | 3 | 0 |  | 0 | 4 | 5 | 6 |  |
| 2 | muli **v0**,**v0**,0x03 | 1 | 2 | 3 | 1 |  | 1 | 6 | 7 | 8 | Wait for v0 |
| 3 | sub **sp**, sp, **v0** | 2 | 3 | 4 | 2 |  | 2 | 8 | 9 | 10 | Wait for v0 |
| 4 | addi a2, **sp**, 24 | 2 | 3 | 4 | 3 |  | 3 | 10 | 11 | 12 | Wait for sp |
| 5 | sub **sp**, **sp**, **v0** | 3 | 4 | 5 | 0 |  | 4 | 11 | 12 | 13 | RS, Wait for sp, Adder |
| 6 | addi a3, **sp**, 24 | 3 | 4 | 7 | 1 |  | 5 | 13 | 14 | 15 | RS, Wait for sp |
| 7 | sub **sp**, **sp**, v0 | 4 | 5 | 9 | 2 |  | 6 | 14 | 15 | 16 | RS, Wait for sp |
| 8 | addi t0, **sp**, 24 | 4 | 7 | 11 | 3 |  | 7 | 16 | 17 | 18 | RS, Wait for sp |
| 9 | sub **sp**, **sp**, v0 | 5 | 9 | 12 | 0 |  | 0 | 17 | 18 | 19 | RS, Wait for sp, Adder |
| 10 | lw **v1**, -32740(**sp**) | 7 | 11 | 14 | 1 | 0 | 1 | 19 | 21 | 22 | RS, Wait for sp |
| 11 | addi a0, **sp**, 24 | 9 | 12 | 15 | 2 |  | 2 | 19 | 20 | 22 | RS, Wait for sp |
| 12 | sub **sp**, **sp**, v0 | 11 | 14 | 17 | 3 |  | 3 | 20 | 21 | 23 | RS, Wait for sp, CD capacity |
| 13 | lw **v0**, -32740(**sp**) | 12 | 15 | 18 | 0 | 1 | 4 | 22 | 24 | 25 | RS, Wait for sp |
| 14 | sw a3, 18732(**v1**) | 14 | 17 | 20 | 1 | 2 | 5 | 23 | 25 | 26 | RS |
| 15 | lw **v1**, -32740(sp) | 15 | 18 | 23 | 2 | 0 | 6 | 26 | 28 | 29 | RS, LSQ, Wait for prev st |
| 16 | sw a2, 18728(**v0**) | 17 | 20 | 26 | 3 | 1 | 7 | 27 | 29 | 30 | RS, LSQ |
| 17 | lw **v0**, -32740(sp) | 18 | 23 | 27 | 0 | 2 | 0 | 30 | 32 | 33 | RS, LSQ, Wait for prev st |
| 18 | sw a0, 18740(**v1**) | 20 | 26 | 30 | 1 | 0 | 1 | 31 | 33 | 34 | RS, LSQ |
| 19 | lw a0, -32740(sp) | 23 | 27 | 31 | 2 | 1 | 2 | 34 | 36 | 37 | RS, LSQ, Wait for prev st |
| 20 | sw t0, 18724(**v0**) | 26 | 30 | 34 | 3 | 2 | 3 | 35 | 37 | 38 | RS, LSQ |
| 21 | lw v0, -32740(sp) | 27 | 31 | 35 | 0 | 0 | 4 | 38 | 40 | 41 | RS, LSQ, Wait for prev st |
| 22 | lw t9, -28608(sp) | 30 | 34 | 38 | 1 | 1 | 5 | 39 | 41 | 42 | RS, LSQ, Wait for prev st |
| 23 | addi **a1**, sp, 24 | 31 | 35 | 38 | 2 |  | 6 | 39 | 40 | 42 | RS |
| 24 | addi a0, a0, 18804 | 34 | 38 | 39 | 3 |  | 7 | 40 | 41 | 43 | RS |
| 25 | addi a2, zero, 124 | 35 | 38 | 39 | 0 |  | 0 | 41 | 42 | 43 | RS, Adder |
| 26 | sw **a1**, 18736(v0) | 38 | 39 | 40 | 1 | 2 | 1 | 41 | 43 | 44 | RS, LSQ, Wait for a1 |
| 27 | move **a1**, zero | 38 | 39 | 40 | 2 |  | 2 | 42 | 43 | 44 | RS, LSQ, Wait for a1 |

# Problem 2.a

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Address | T/NT | Entry | Predicti on | Correct  ? | Predictor State (0, 1, 2, 3) | | | |
| 0x4652a8 | NT | 0 | NT | Yes | 0 | 0 | 0 | 0 |
| 0x4652b1 | NT | 1 | NT | Yes | 0 | 0 | 0 | 0 |
| 0x4652b3 | T | 3 | NT | No | 0 | 0 | 0 | 1 |
| 0x4652c1 | NT | 1 | NT | Yes | 0 | 0 | 0 | 1 |
| 0x4652c2 | NT | 2 | NT | Yes | 0 | 0 | 0 | 1 |
| 0x465300 | T | 0 | NT | No | 1 | 0 | 0 | 1 |
| 0x4652a8 | NT | 0 | NT | Yes | 0 | 0 | 0 | 1 |
| 0x4652b1 | NT | 1 | NT | Yes | 0 | 0 | 0 | 1 |
| 0x4652b3 | NT | 3 | NT | Yes | 0 | 0 | 0 | 0 |
| 0x4652c1 | T | 1 | NT | No | 0 | 1 | 0 | 0 |
| 0x4652c2 | NT | 2 | NT | Yes | 0 | 1 | 0 | 0 |
| 0x465300 | T | 0 | NT | No | 1 | 1 | 0 | 0 |
| 0x4652a8 | NT | 0 | NT | Yes | 0 | 1 | 0 | 0 |
| 0x4652b1 | T | 1 | NT | No | 0 | 2 | 0 | 0 |
| 0x4652b3 | T | 3 | NT | No | 0 | 2 | 0 | 1 |
| 0x4652c1 | T | 1 | T | Yes | 0 | 3 | 0 | 1 |
| 0x4652c2 | NT | 2 | NT | Yes | 0 | 3 | 0 | 1 |
| 0x465300 | T | 0 | NT | No | 1 | 3 | 0 | 1 |
| 0x4652a8 | T | 0 | NT | No | 2 | 3 | 0 | 1 |
| 0x4652b3 | NT | 3 | NT | Yes | 2 | 3 | 0 | 0 |
| 0x4652a8 | NT | 0 | T | No | 1 | 3 | 0 | 0 |
| 0x4652b1 | T | 1 | T | Yes | 1 | 3 | 0 | 0 |
| 0x4652c1 | T | 1 | T | Yes | 1 | 3 | 0 | 0 |
| 0x4652c2 | NT | 2 | NT | Yes | 1 | 3 | 0 | 0 |
| 0x465300 | T | 0 | NT | No | 2 | 3 | 0 | 0 |



2

3

0

1

FSM for 2 bit counter

# Problem 2.b

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Address | T/NT | Pred? | Coor? | Predictor State (0, 1, 2, …, 7) | | | | | | | |
| 0x4652a8 | NT | NT | Yes | 0**0**0 | 000 | 000 | 000 | 000 | 000 | 000 | 000 |
| 0x4652b1 | NT | NT | Yes |  | 0**0**0 |  |  |  |  |  |  |
| 0x4652b3 | T | NT | No |  |  |  | 1**1**0 |  |  |  |  |
| 0x4652c1 | NT | NT | Yes |  | 0**0**0 |  |  |  |  |  |  |
| 0x4652c2 | NT | NT | Yes |  |  | 0**0**0 |  |  |  |  |  |
| 0x465300 | T | NT | No | 1**1**0 |  |  |  |  |  |  |  |
| 0x4652a8 | NT | NT | Yes | 01**0** |  |  |  |  |  |  |  |
| 0x4652b1 | NT | NT | Yes |  | 0**0**0 |  |  |  |  |  |  |
| 0x4652b3 | NT | NT | Yes |  |  |  | 01**0** |  |  |  |  |
| 0x4652c1 | T | NT | No |  | 1**1**0 |  |  |  |  |  |  |
| 0x4652c2 | NT | NT | Yes |  |  | 0**0**0 |  |  |  |  |  |
| 0x465300 | T | T | Yes | 1**1**0 |  |  |  |  |  |  |  |
| 0x4652a8 | NT | NT | Yes | 01**0** |  |  |  |  |  |  |  |
| 0x4652b1 | T | NT | No |  | 11**1** |  |  |  |  |  |  |
| 0x4652b3 | T | T | Yes |  |  |  | 1**1**0 |  |  |  |  |
| 0x4652c1 | T | T | Yes |  | 11**1** |  |  |  |  |  |  |
| 0x4652c2 | NT | NT | Yes |  |  | 0**0**0 |  |  |  |  |  |
| 0x465300 | T | T | Yes | 1**1**0 |  |  |  |  |  |  |  |
| 0x4652a8 | T | NT | No | 11**1** |  |  |  |  |  |  |  |
| 0x4652b3 | NT | NT | Yes |  |  |  | 01**0** |  |  |  |  |
| 0x4652a8 | NT | T | No | 01**0** |  |  |  |  |  |  |  |
| 0x4652b1 | T | T | Yes |  | 11**1** |  |  |  |  |  |  |
| 0x4652c1 | T | T | Yes |  | 11**1** |  |  |  |  |  |  |
| 0x4652c2 | NT | NT | Yes |  |  | 0**0**0 |  |  |  |  |  |
| 0x465300 | T | T | Yes | 1**1**0 |  |  |  |  |  |  |  |