COMPUTER ARCHITECTURES

02LSEOQ  
02LSEOV

LAB 04. – WINMIPS

Considering a MIPS architecture with the following characteristics:

* Integer ALU: 1 clock cycle
* Data memory: 1 clock cycle
* FP arithmetic unit: pipelined, 2 clock cycles
* FP multiplier unit: pipelined, 6 clock cycles
* FP divider unit: not pipelined, 10 clock cycles

Assume also:

* branch delay slot corresponding to 1 clock cycle, branch delay slot not enabled
* data forwarding enabled
* EXE stage could be completed also in out-of-order fashion.

Given the codes provided, esteem the number of clock cycles needed for completion.

Also, fill up the tables with the pipeline stages at each clock cycle (this is needed only for one iteration of the loop).

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**EX. 00**

; \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* MIPS64 \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

; for (i = 0; i < 10; i++) {

; v5[i] = v1[i]\*v2[i] - v3[i]/v4[i];

; }

|  |  |  |
| --- | --- | --- |
| .data | comments | Clock cycles |
| V1: .double “10 values” |  |  |
| V2: .double “10 values” |  |  |
| V3: .double “10 values”  …  V5: .double “10 zeros” |  |  |
|  |  |
|  |  |
|  |  |
| .text |  |  |
| main: daddui r1,r0,0 | r1← pointer | 5 |
| daddui r2,r0,10 | r2 <= 10 | 1 |
| loop: l.d f1,v1(r1) | f1 <= v1[i] | 1 |
| l.d f2,v2(r1) | f2 <= v2[i] | 1 |
| mul.d f5,f1,f2 | f5 <= v1[i]\*v2[i] | 7 |
| l.d f3,v3(r1) | f3 <= v3[i] | 0 |
| l.d f4,v4(r1) | f4 <= v4[i] | 0 |
| div.d f6, f3, f4 | f6 <= v3[i]/v4[i] | 8 |
| sub.d f5,f5,f6 | f5 <= f5-f6 | 2 |
| s.d f5,v5(r1) | v5[i] <= f5 | 1 |
| daddui r1,r1,8 | r1 <= r1 + 8 | 1 |
| daddi r2,r2,-1 | r2 <= r2 - 1 | 1 |
| bnez r2,loop |  | 2 |
| halt |  | 1 |
| total |  | 256 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| daddui r1,r0,0 | F | D | E | M | W |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| daddui r2,r0,20 |  | F | D | E | M | W |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| l.d f1,v1(r1) |  |  | F | D | E | M | W |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| l.d f2,v2(r1) |  |  |  | F | D | E | M | W |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| mul.d f5,f1,f2 |  |  |  |  | F | D |  | E | E | E | E | E | E | M | W |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| l.d f3,v3(r1) |  |  |  |  |  | F |  | D | E | M | W |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| l.d f4,v4(r1) |  |  |  |  |  |  |  | F | D | E | M | W |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| div.d f6, f3, f4 |  |  |  |  |  |  |  |  | F | D |  | E | E | E | E | E | E | E | E | E | E | M | W |  |  |  |  |  |  |  |  |  |  |  |
| sub.d f5,f5,f6 |  |  |  |  |  |  |  |  |  | F |  | D |  |  |  |  |  |  |  |  | E | E | M | W |  |  |  |  |  |  |  |  |  |  |
| s.d f5,v5(r1) |  |  |  |  |  |  |  |  |  |  |  | F |  |  |  |  |  |  |  |  | D | E |  | M | W |  |  |  |  |  |  |  |  |  |
| daddui r1,r1,8 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | F | D |  | E | M | W |  |  |  |  |  |  |  |  |
| daddi r2,r2,-1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | F |  | D | E | M | W |  |  |  |  |  |  |  |
| bnez r2,loop |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | F |  | D | E | M | W |  |  |  |  |  |
| halt |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | F | D | E | M | W |  |  |  |  |

IF ID EX Mem WB

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**EX. 01**

; \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* MIPS64 \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

for (i = 0; i < 30; i++){

v5[i] = (v1[i]\*v2[i]) + v3[i];

v6[i] =(v3[i]\*v4[i])/v5[i]:

}

|  |  |  |
| --- | --- | --- |
| .data | comments | Clock cycles |
| V1: .double “30 values” |  |  |
| V2: .double “30 values” |  |  |
| V3: .double “30 values”  …  V5: .space 240  V6: .space 240 |  |  |
|  |  |
|  |  |
|  |  |
| .text |  |  |
| main: daddui r2,r0,0 | r2← pointer | 5 |
| daddui r1,r0,30 | r1 <= 30 | 1 |
| cycle: l.d f3,v1(r2) | f3 <= v1[i] | 1 |
| l.d f4,v2(r2) | f4 <= v2[i] | 1 |
| l.d f5,v3(r2); | f5 <= v3[i] | 1 |
| l.d f6,v4(r2) | f6 <= v4[i] | 1 |
| mul.d f3,f3,f4; | f3 = f3\*f4 | 6 |
| mul.d f7,f5,f6; | f7 = f5\*f6 | 1 |
| daddi r1,r1,-1; | … | 0 |
| add.d f4,f5,f3; | … | 1 |
| div.d f7,f7,f4; | … | 10 |
| s.d f4,v5(r2); | … | 0 |
| s.d f7,v6(r2) | … | 1 |
| daddui r2,r2,8; | … | 1 |
| bnez r1,cycle; | … | 1 |
| halt |  | 1 |
|  |  |  |
| total |  | 786 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| daddui r2,r0,0; | F | D | E | M | W |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| daddui r1,r0,30; |  | F | D | E | M | W |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| l.d f3,v1(r2); |  |  | F | D | E | M | W |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| l.d f4,v2(r2); |  |  |  | F | D | E | M | W |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| l.d f5,v3(r2); |  |  |  |  | F | D | E | M | W |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| l.d f6,v4(r2); |  |  |  |  |  | F | D | E | M | W |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| mul.d f3,f3,f4; |  |  |  |  |  |  | F | D | E | E | E | E | E | E | M | W |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| mul.d f7,f5,f6; |  |  |  |  |  |  |  | F | D | E | E | E | E | E | E | M | W |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| daddi r1,r1,-1; |  |  |  |  |  |  |  |  | F | D | E | M | W |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| add.d f4,f5,f3; |  |  |  |  |  |  |  |  |  | F | D |  |  |  | E | E | M | W |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| div.d f7,f7,f4; |  |  |  |  |  |  |  |  |  |  | F |  |  |  | D |  | E | E | E | E | E | E | E | E | E | E | M | W |  |  |  |  |  |  |
| s.d f4,v5(r2); |  |  |  |  |  |  |  |  |  |  |  |  |  |  | F |  | D | E | M | W |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| s.d f7,v6(r2); |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | F | D |  |  |  |  |  |  |  |  | E | M | W |  |  |  |  |  |
| daddui r2,r2,8; |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | F |  |  |  |  |  |  |  |  | D | E | M | W |  |  |  |  |
| bnez r1,cycle; |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | F | D | E | M | W |  |  |  |
| halt |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | F |  |  |  |  |  |  |