```
.data
vect1:   .word 0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15
vect2:   .word 0,2,4,6,8,10,12,14,16,18,20,22,24,26,28,30
vect3:   .zero 64

.text
   1 la x10, vect1
   1 la x11, vect2
   2 la x12, vect3
   1 li x13, 0
   1 li x14, 16
loop:
   1   beq x13, x14, end
   1   slli x15, x13, 2
   1   add x15, x15, x10
   1   lw x16, 0(x15)

   1   slli x15, x13, 2
   1   add x15, x15, x11
   1   lw x17, 0(x15)

   1   add x16, x16, x17

   1   slli x15, x13, 2
   1   add x15, x15, x12
   1   sw x16, 0(x15)

   1   addi x13, x13, 1
   1   j loop   # jalr x0, x0, loop
end:
```

CC → Conflito Controlo
CD → Conflito dados

beq x13, x14, end ← CD e CC ⟩2NOPS ⌐3NOPS
slli x15, x13, 2 ← CD
add x15, x15, x10 ← CD ⌐3NOPS
lw x16, 0(x15) ← CD ⟩3NOP

slli x15, x13, 2 ⟩3NOP
add x15, x15, x11 ← CD ⟩3NOP
lw x17, 0(x15) ← CD

add x16, x16, x17 ← CD ⟩3NOP

slli x15, x13, 2 ⟩3NOP
add x15, x15, x12 ← CD ⟩3NOP
sw x16, 0(x15) ← CD

j loop ⟩2NOP

a) $5 + 16 \times 12 + 17 = 214$ ciclos   esvaziar a pipeline

b) Reordenando o código : $5 + 16 \times 18 + 17 + 4 = 314$

c)

$2GHz = 2000$ MHz $T_{cada único} = 0,43$

$T_{CLKO} = 4 T_{CLK \, pipe}$ $T_{pipeline} = 0,16$

Speedup $\dfrac{4 \cdot 214}{314} = 2,73$

all $\dfrac{0,43}{0,16}$

4) 4 linhas de forwarding

WB → IDA
EX → IDA
MEM → IDA
EX → ID B   mas o jal

$5 + 17 + 16 \times 11 + 2 \times 16 + 32 + 4 = 266$
                                stall

$\dfrac{266}{2000 \times 1,1} = 0,1403$ $\dfrac{0,43}{0,1463} = 2,93$