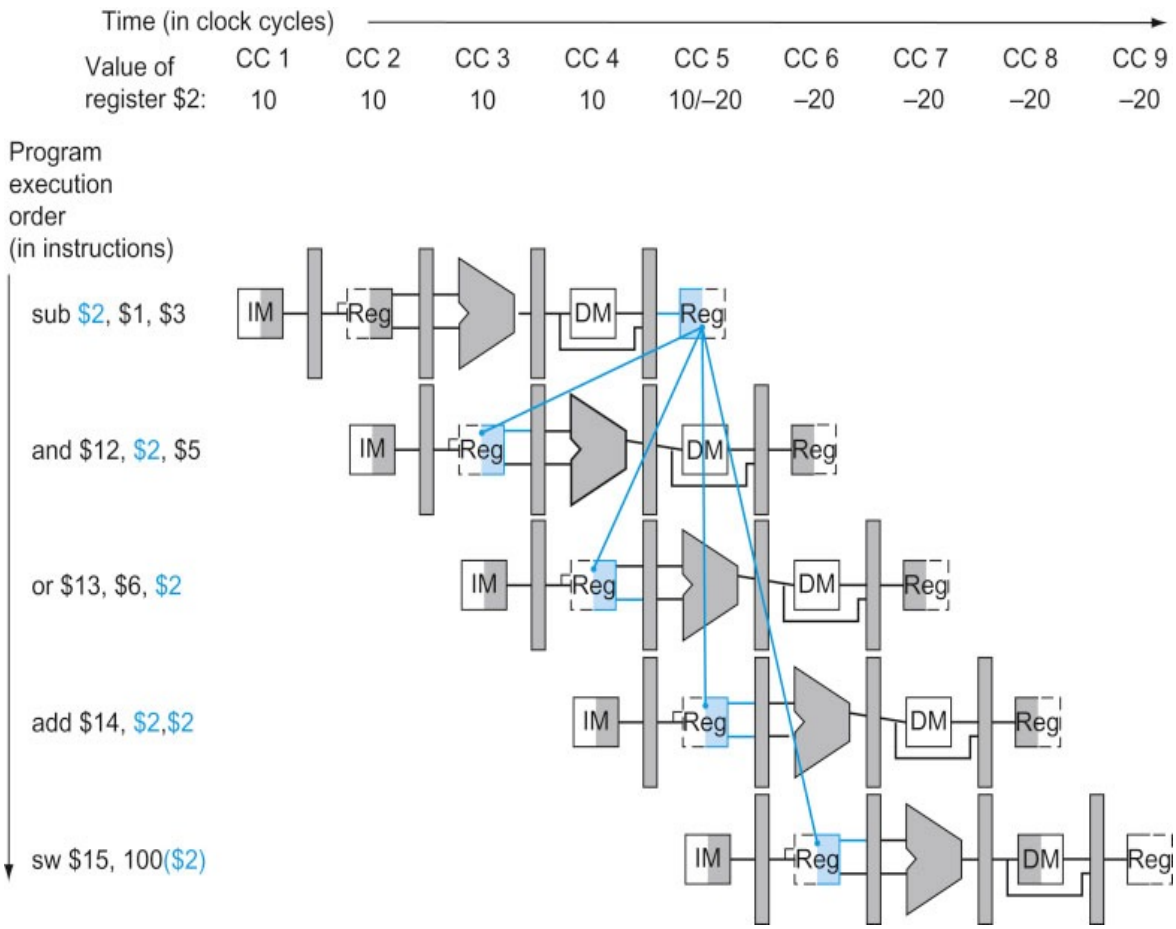
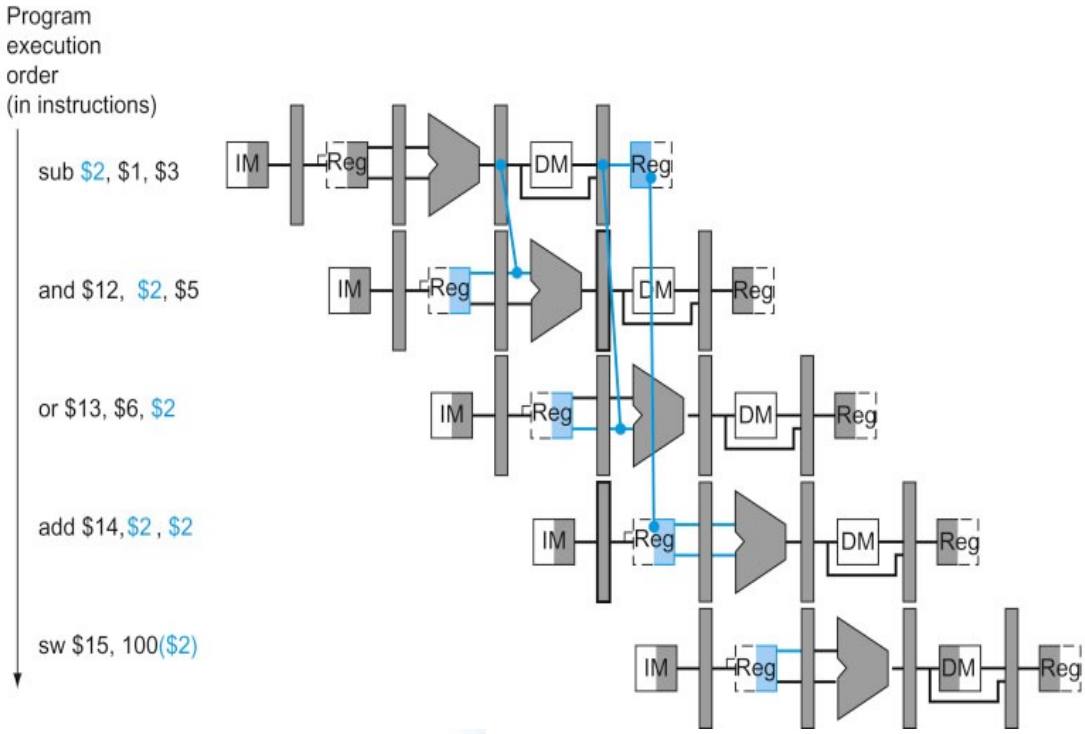
Dependencias de datos

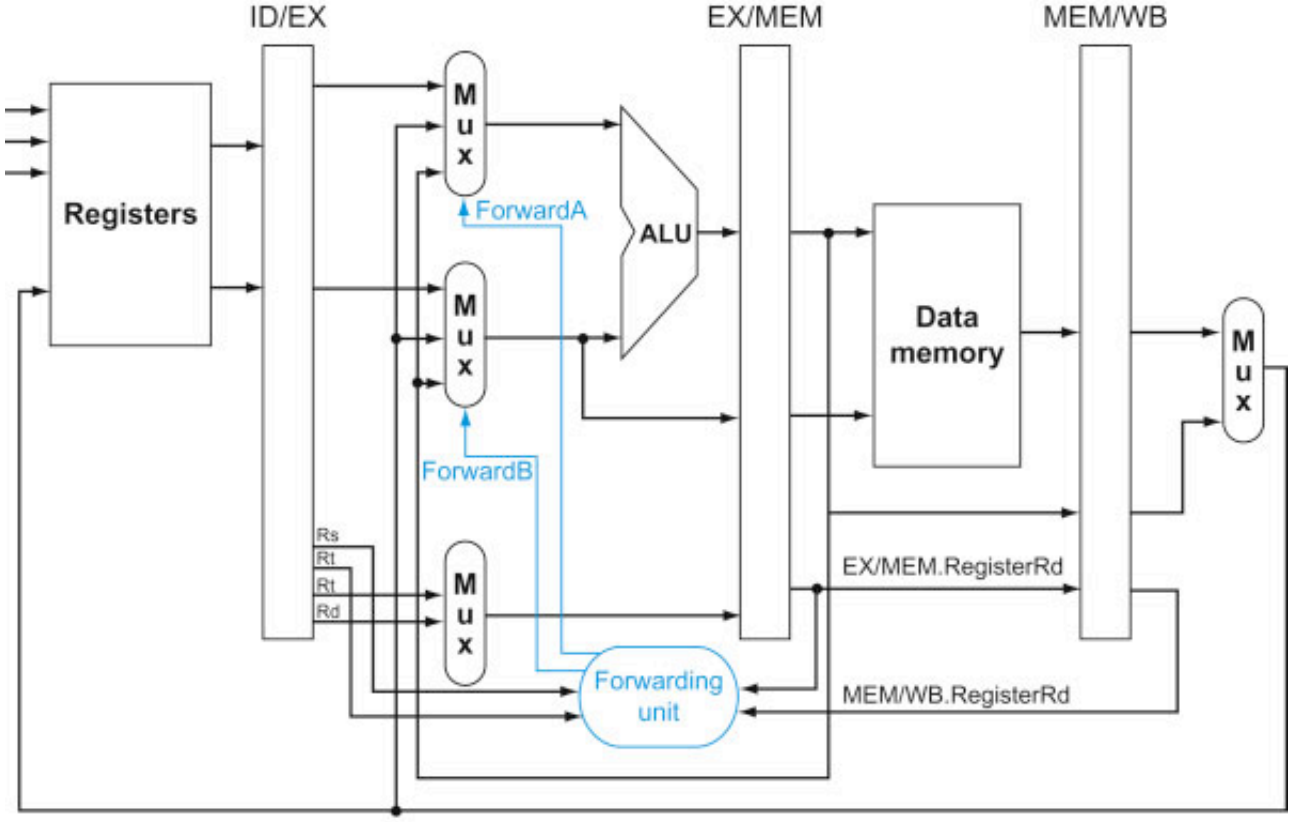
sub $2, $1, $3
and $12, $2, $5
or $13, $6, $2
add $14, $2, $2
sw $15, 100($2)



Time (in clock cycles)	CC 1	CC 2	CC 3	CC 4	CC 5	CC 6	CC 7	CC 8	CC 9
Value of register $2:	10	10	10	10	10/–20	–20	–20	–20	–20
Value of EX/MEM:	X	X	X	–20	X	X	X	X	X
Value of MEM/WB:	X	X	X	X	–20	X	X	X	X



Nuevo hardware para adelantamiento

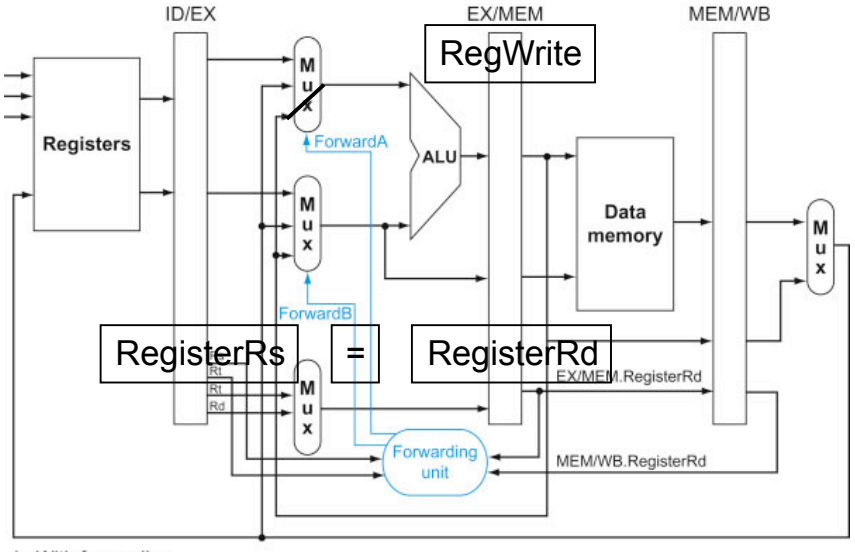


Control de los multiplexores para adelantamiento

Mux control	Source	Explanation
ForwardA = 00	ID/EX	The first ALU operand comes from the register file.
ForwardA = 10	EX/MEM	The first ALU operand is forwarded from the prior ALU result.
ForwardA = 01	MEM/WB	The first ALU operand is forwarded from data memory or an earlier ALU result.
ForwardB = 00	ID/EX	The second ALU operand comes from the register file.
ForwardB = 10	EX/MEM	The second ALU operand is forwarded from the prior ALU result.
ForwardB = 01	MEM/WB	The second ALU operand is forwarded from data memory or an earlier ALU result.

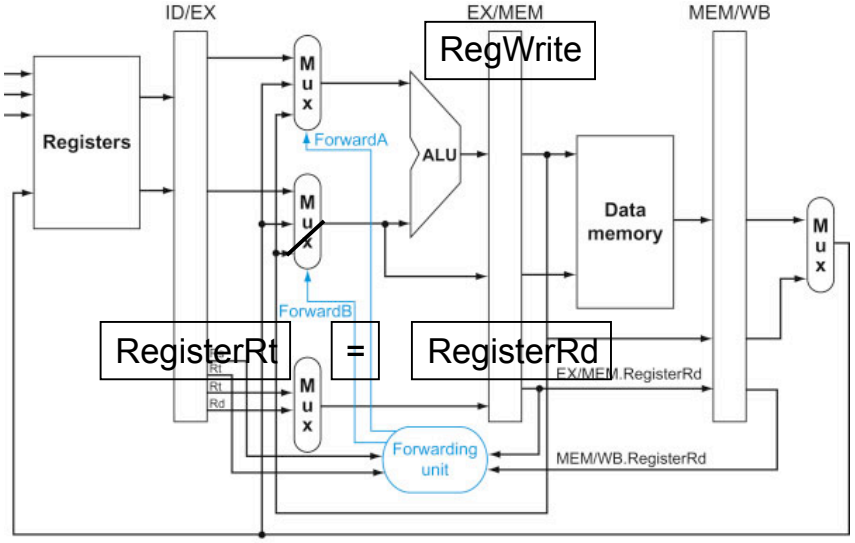
Condiciones para detectar riesgos. Señales de control. Riesgo con EX

if (EX/MEM.RegWrite
and (EX/MEM.RegisterRd ≠ 0)
and (EX/MEM.RegisterRd = ID/EX.RegisterRs)) ForwardA=10



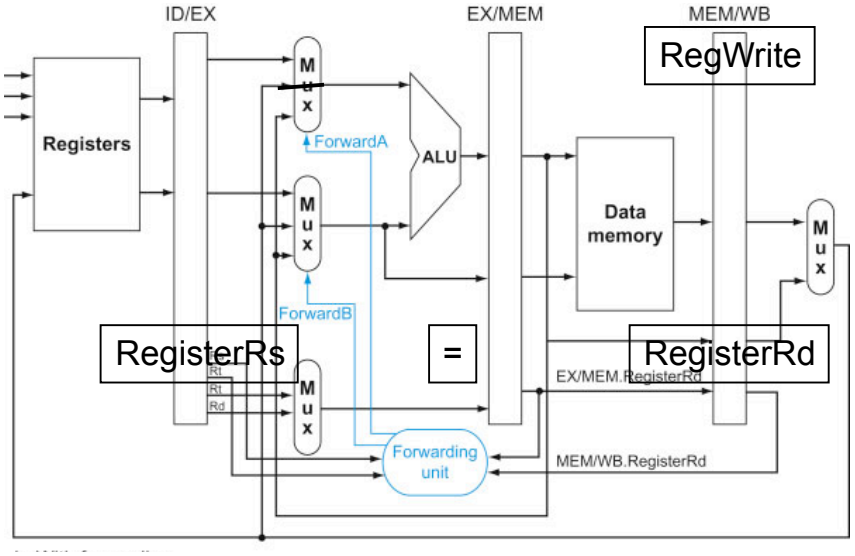
Condiciones para detectar riesgos. Señales de control. Riesgo con EX

if (EX/MEM.RegWrite
and (EX/MEM.RegisterRd ≠ 0)
and (EX/MEM.RegisterRd = ID/EX.RegisterRt)) ForwardB=10



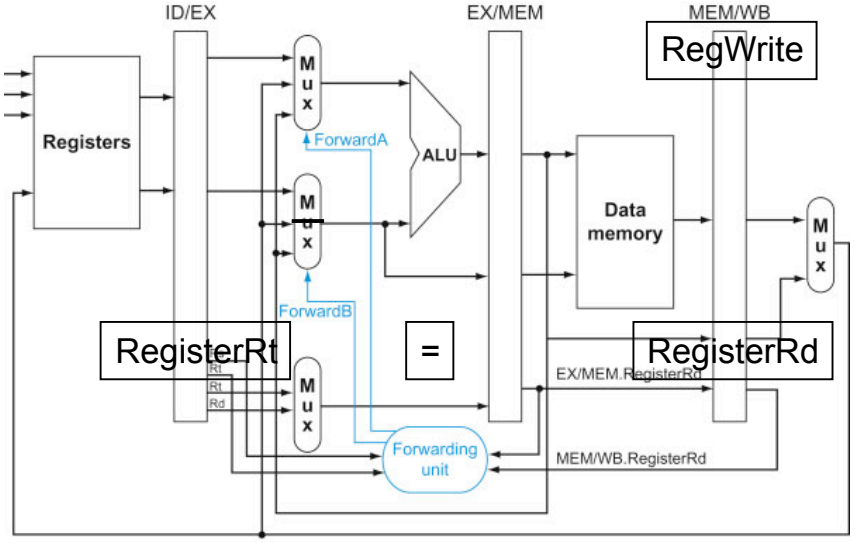
Condiciones para detectar riesgos. Señales de control. Riesgo con MEM

if (MEM/WB.RegWrite
and (MEM/WB.RegisterRd ≠ 0)
and (MEM/WB.RegisterRd = ID/EX.RegisterRs)) ForwardA=01



Condiciones para detectar riesgos. Señales de control. Riesgo con MEM

if (MEM/WB.RegWrite
and (MEM/WB.RegisterRd ≠ 0)
and (MEM/WB.RegisterRd = ID/EX.RegisterRt)) ForwardB=01

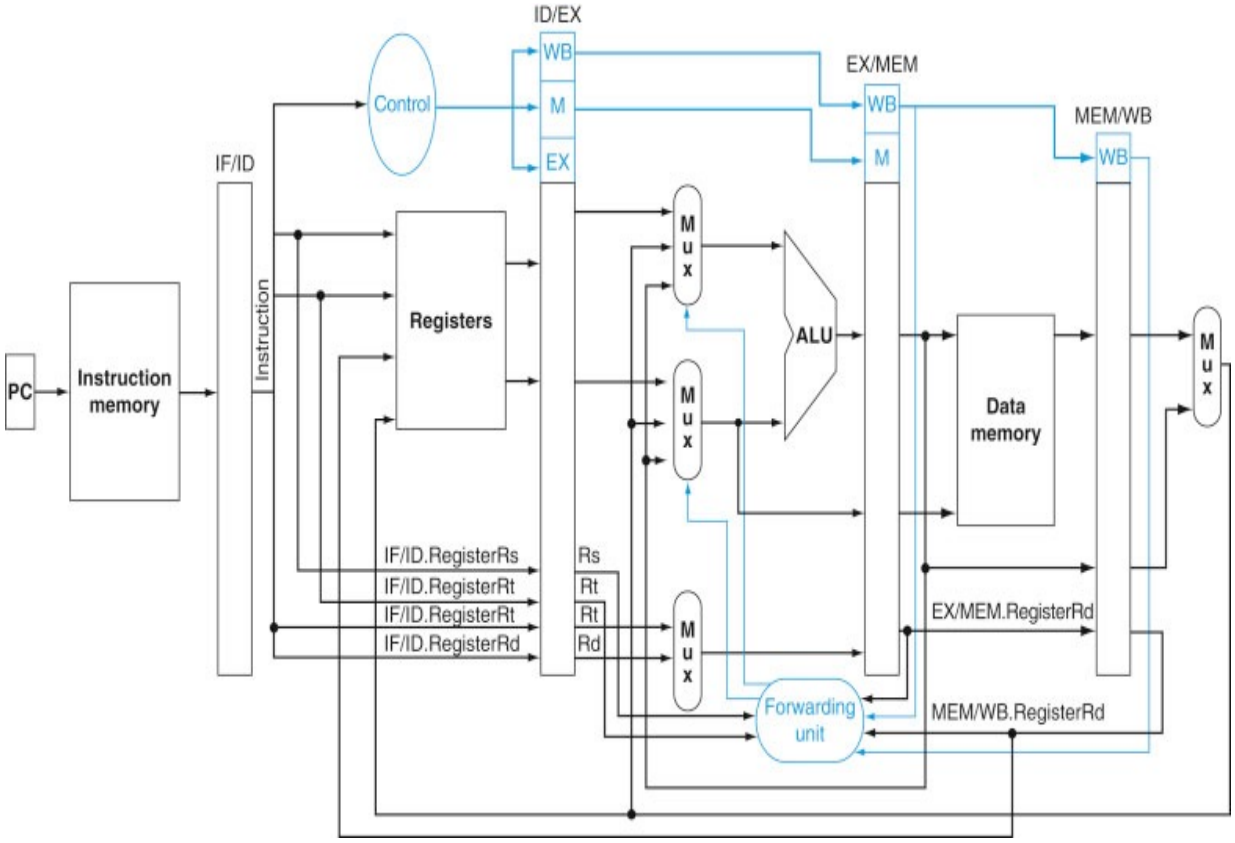


Conflicto: sumar un vector de números

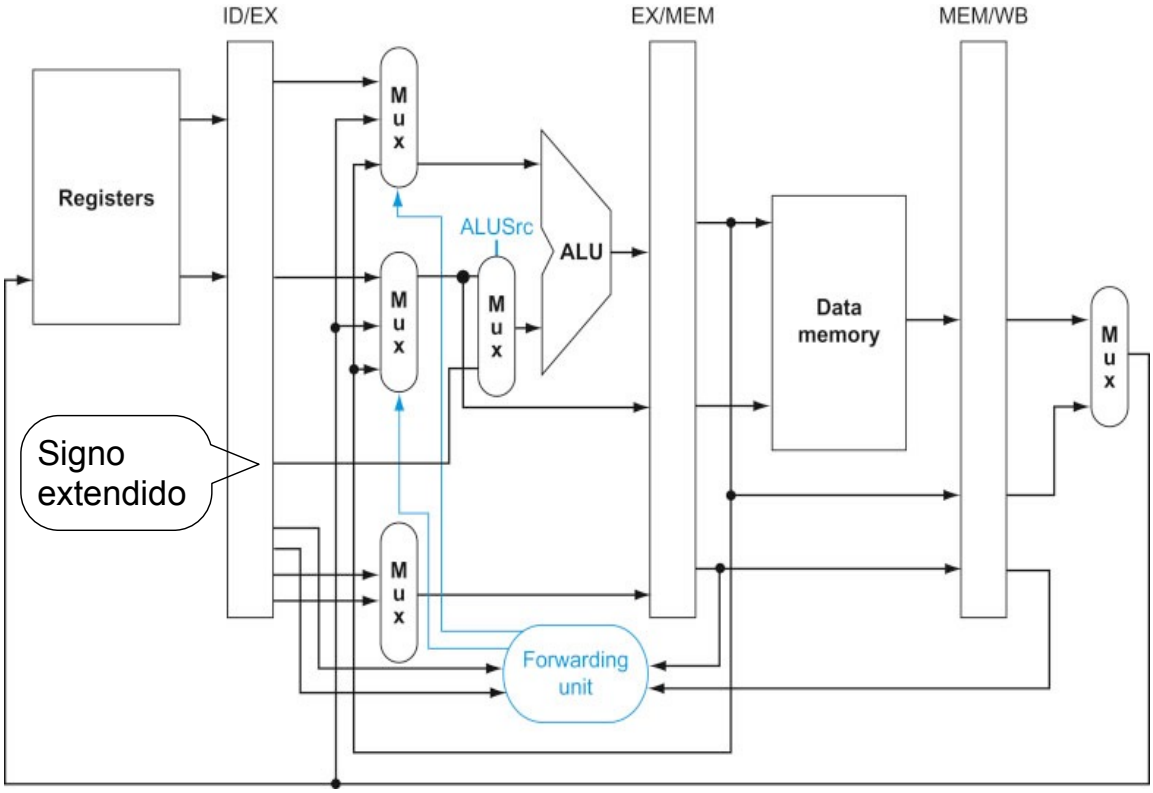
if (MEM/WB.RegWrite
and (MEM/WB.RegisterRd ≠ 0)
and not(EX/MEM.RegWrite and (EX/MEM.RegisterRd ≠ 0)
and (EX/MEM.RegisterRd = ID/EX.RegisterRs))
and (MEM/WB.RegisterRd = ID/EX.RegisterRs)) ForwardA=01

if (MEM/WB.RegWrite
and (MEM/WB.RegisterRd ≠ 0)
and not(EX/MEM.RegWrite and (EX/MEM.RegisterRd ≠ 0)
and (EX/MEM.RegisterRd = ID/EX.RegisterRt))
and (MEM/WB.RegisterRd = ID/EX.RegisterRt)) ForwardB=01

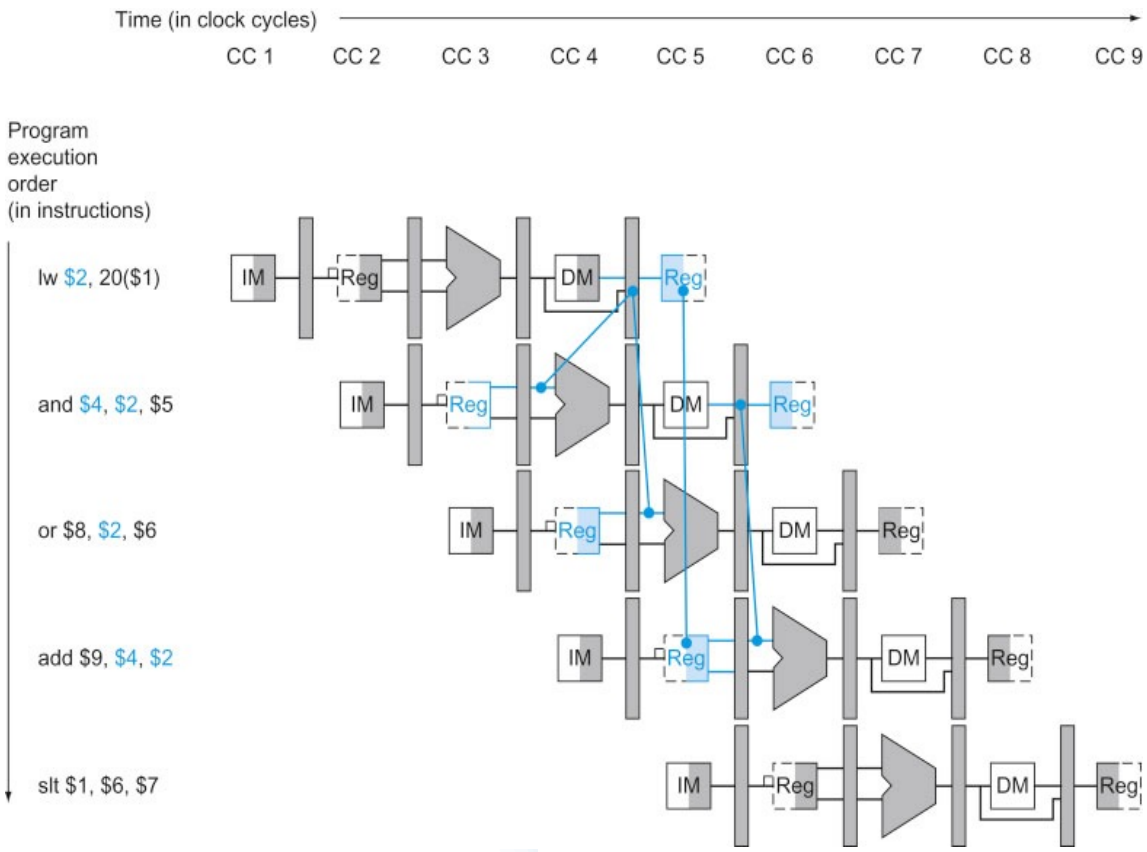
Resolución de riesgos con adelantamiento



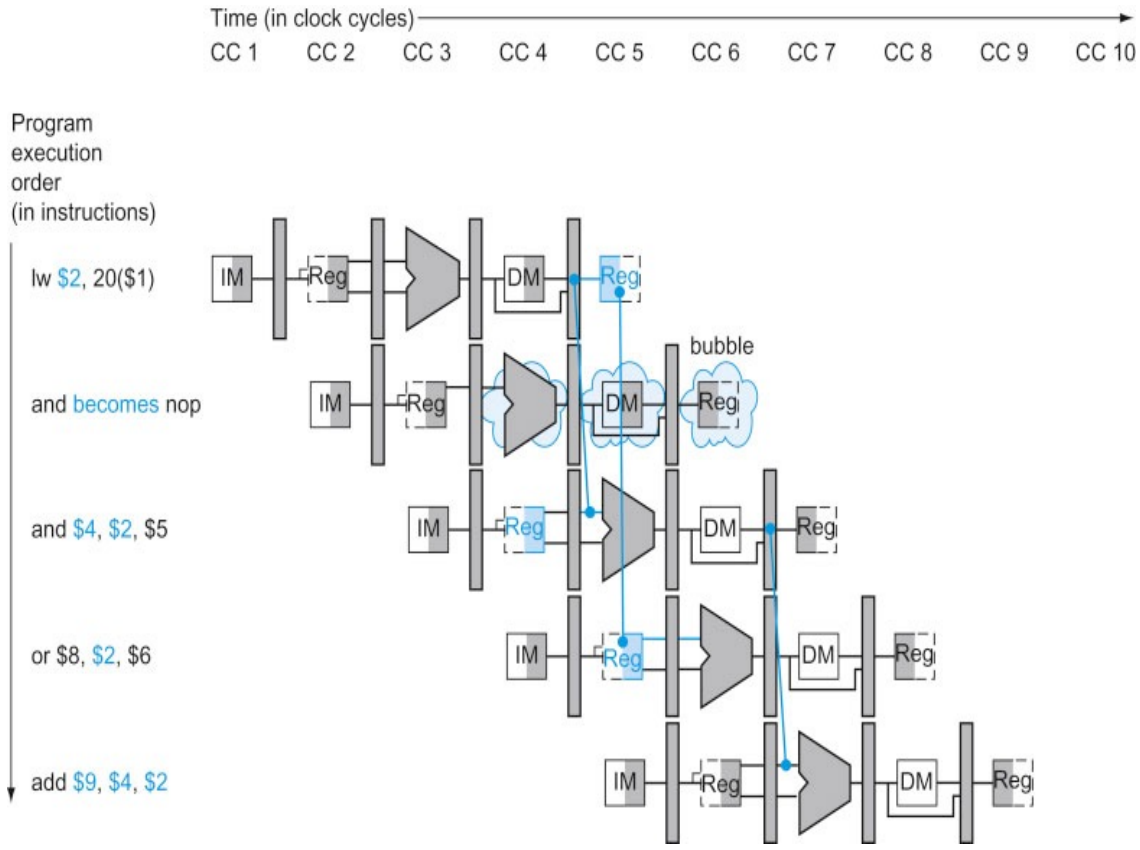
Detalle de opciones en la entrada de la ALU



Riesgo load-use



Riesgo load-use



Detección de riesgo load-use

if (ID/EX.MemRead and
((ID/EX.RegisterRt = IF/ID.RegisterRs) or
(ID/EX.RegisterRt = IF/ID.RegisterRt)))
atasco

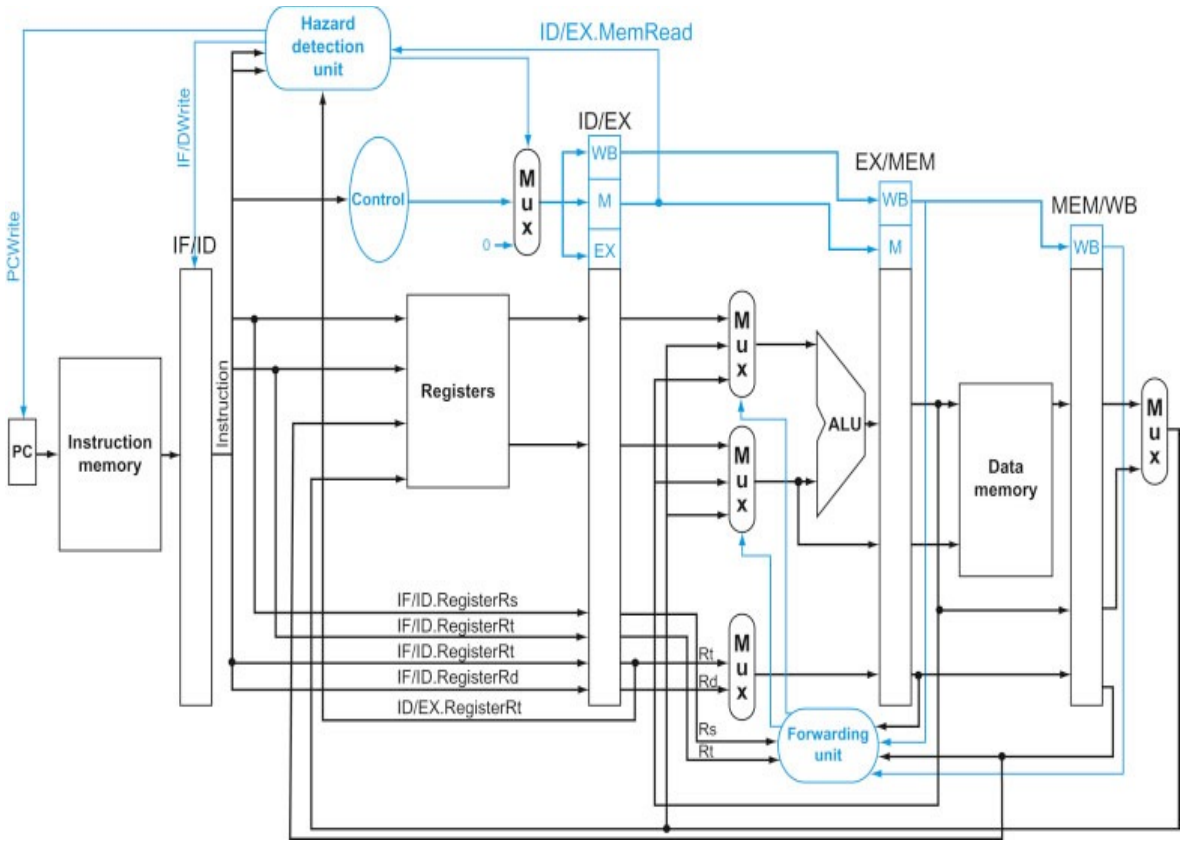
No se modifican ni PC ni el registro IF/ID

Se crea una burbuja en EX. Una nop

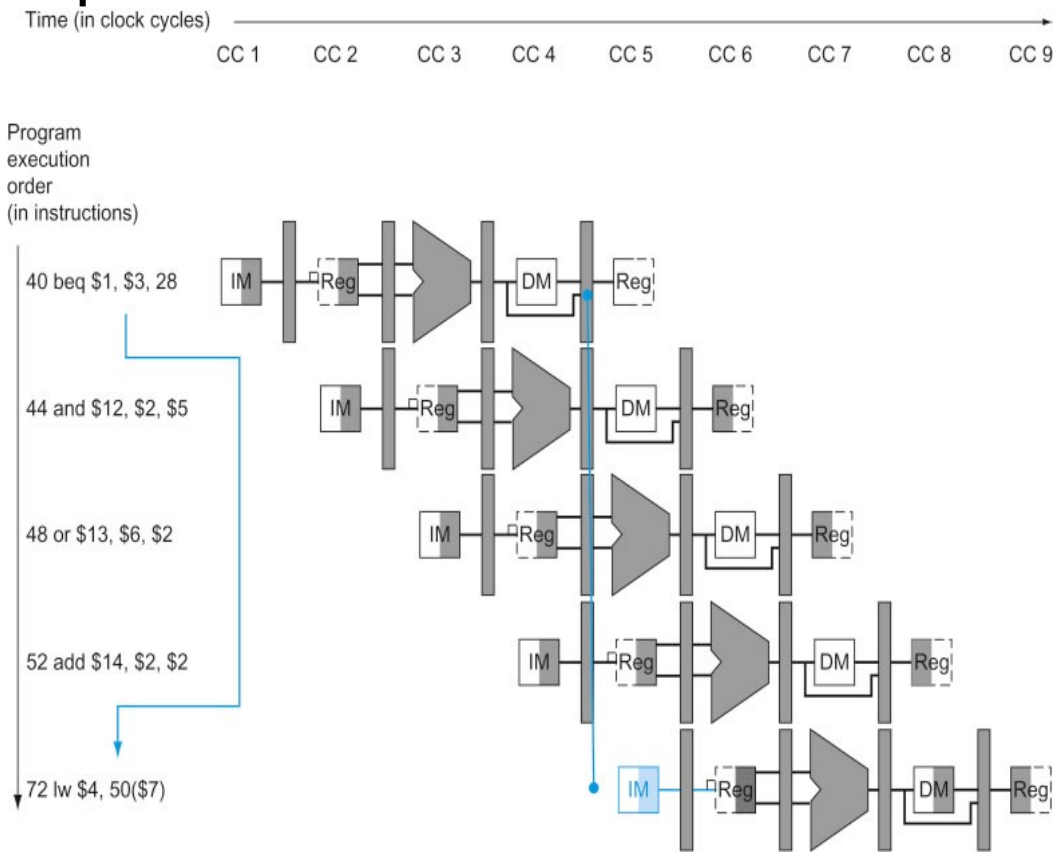
Una nop son todos ceros

Las instrucciones posteriores se demoran 1 ciclo

Unidades de riesgo y de adelantamiento



Impacto de los saltos condicionales



Riesgos de control

Atascar hasta completar el salto es ineficiente.

Predecir como salto no tomado:

- Acierto: sin costo
- Fallo: descartar (flush) instrucciones

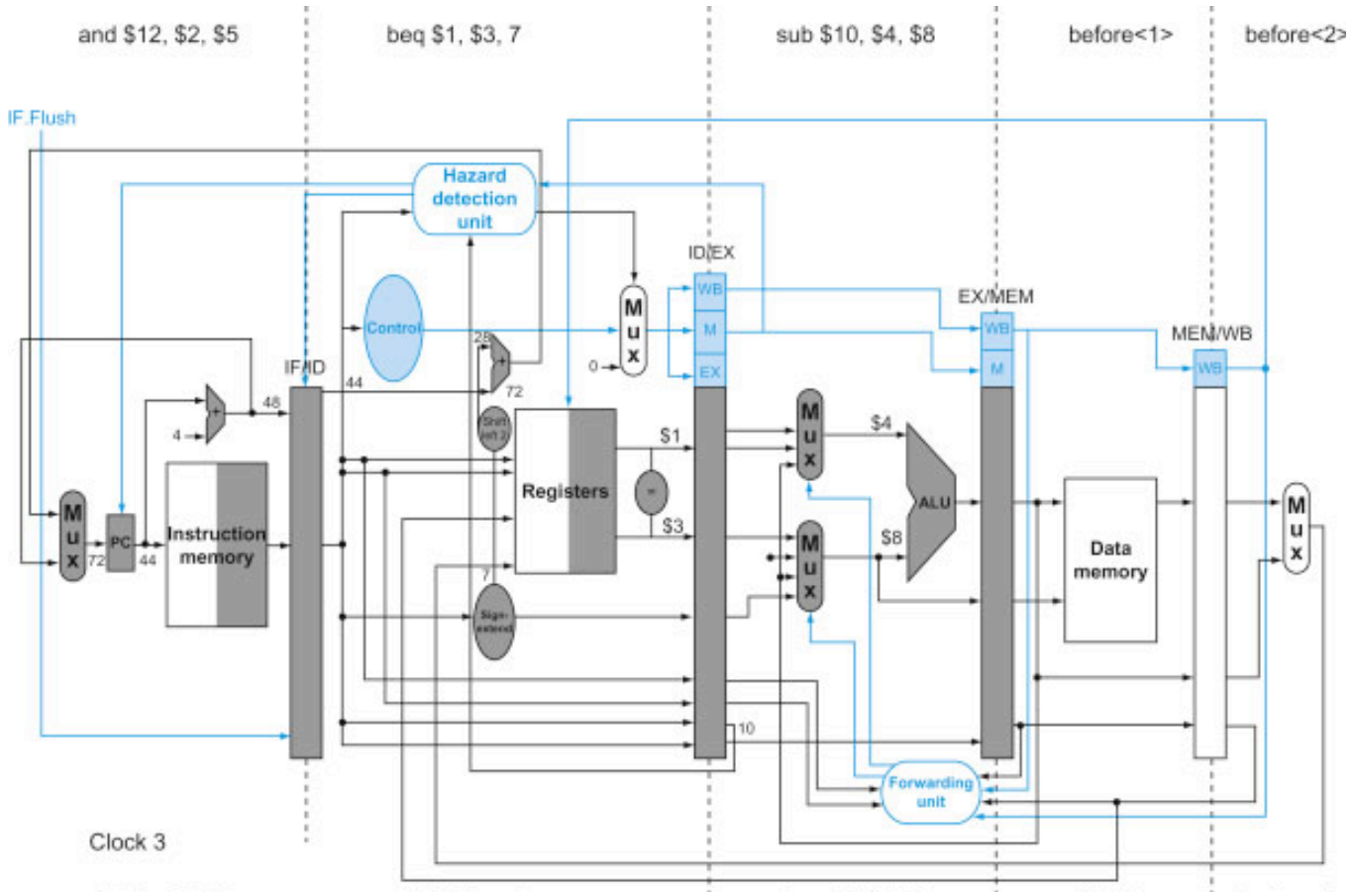
Reduciendo las demoras por saltos.

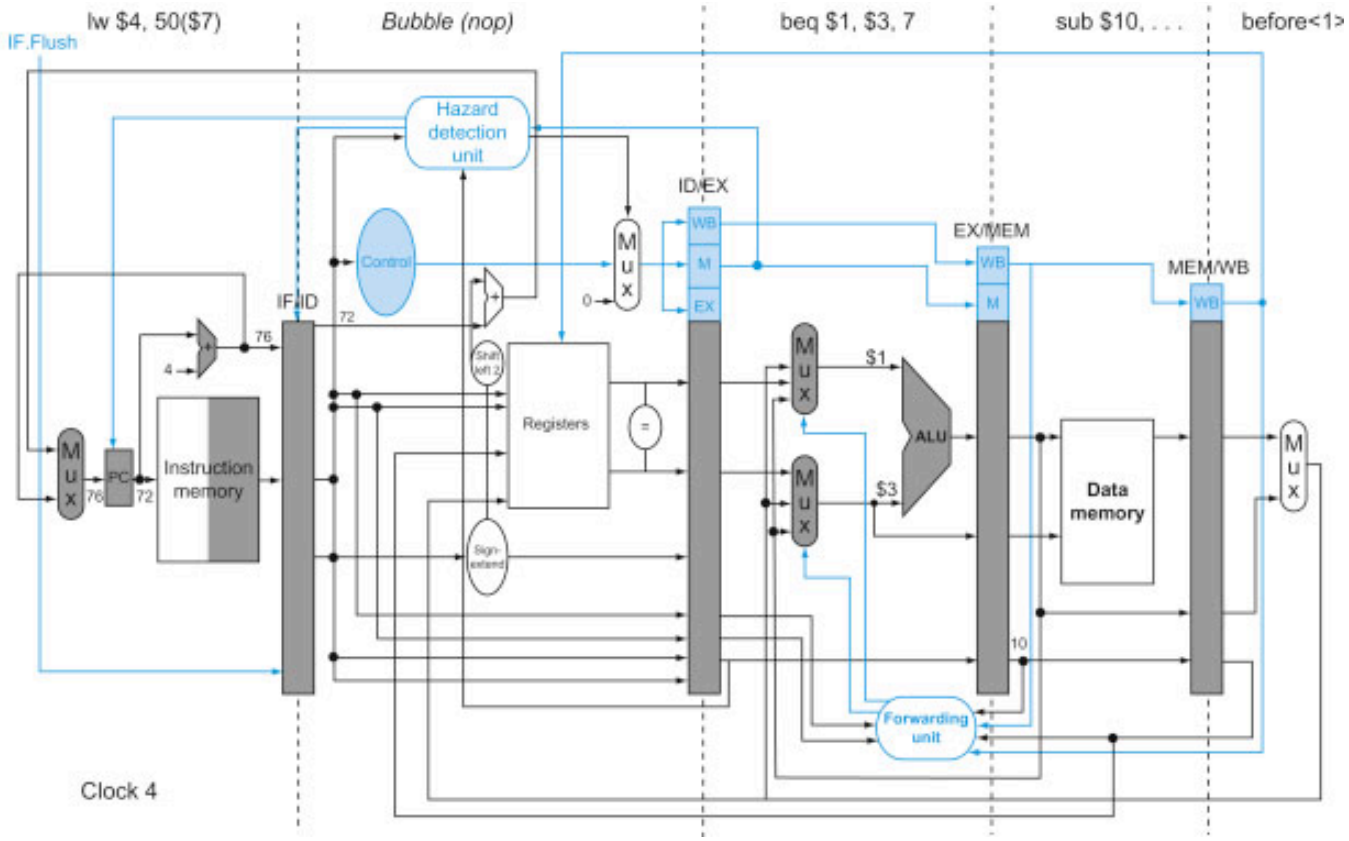
- Adelantar la ejecución elimina menos instrucciones.
- Colocar el sumador para saltos en ID.
- Una simple comparación no requiere una ALU.
- Se requiere adelantamiento.

Optimización del salto tomado

```
36  sub $10, $4, $8
40  beq $1, $3, 7
44  and $12, $2, $5
48  or  $13, $2, $6
52  add $14, $4, $7
...  ...
72  lw  $4, 50($7)
```

Salto relativo al PC a 72 (40+4+7*4)





¿Qué vimos?

Dependencia de datos

Adelantamiento: circuitos y controles

Riesgo load-use

Riesgos de control

- Salto no tomado
- Penalidad