Pipeline with Data Forwarding

Solving Data hazards
Data Hazards

Loop:

addi $t0, $t0, 4
beq $t0, $s1, endLoop
add $t1, $t0, $s0
add $t2, $t0, $s4
lw $t3, 0($t1)
lw $t4, 0($t2)
add $t3, $t4, $t3
sw $t3, 0($t1)

j Loop

endLoop:
Unavoidable data hazards

- `lw` data to immediately following instruction
  - one cycle stall
- ALU to immediately following branch
  - one cycle stall
- `lw` to immediately following branch
  - two cycle stall
- Stalls need circuits to freeze PC and to place 0’s in control line registers
Unavoidable Data Hazards

Loop:

```
addi $t0, $t0, 4
beq $t0, $s1, endLoop
add $t1, $t0, $s0
add $t2, $t0, $s4
lw $t3, 0($t1)
lw $t4, 0($t2)
add $t3, $t4, $t3
sw $t3, 0($t1)
j Loop
```

d endLoop:

Can we reorder code to fix??
Reordered

addi $t0, $t0, 4  

Loop:  
add $t1, $t0, $s0  
beq $t0, $s1, endLoop  
add $t2, $t0, $s4  
lw $t3, 0($t1)  
lw $t4, 0($t2)  
addi $t0, $t0, 4  
add $t3, $t4, $t3  
sw $t3, 0($t1)  
j Loop  

endLoop:

No longer a problem
Branch forwarding