Pipeline with Data Forwarding

Solving Data hazards
Data Hazards

Loop:

```
sub X9, X9, 4
cbz X9, endLoop
add X10, X9, X19
add X11, X9, X23
ldur X12, [X10, #0]
ldur X13, [X11, #0]
add X12, X13, X12
stur X12, [X10, #0]
```

```
b   Loop
```

endLoop:
null
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
HAZARD Control freezes appropriate instructions in place by not allowing writes to pipeline registers and zeroes control pipeline registers to create bubble.
Data Hazards

Loop:

```
sub X9, X9, 4
cbz X9, endLoop
add X10, X9, X19
add X11, X9, X23
ldur X12, [X10, #0]
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add X12, X13, X12
stur X12, [X10, #0]
b Loop
```

endLoop:

Can we reorder code to fix??
Reordered

sub X9, X9, 4
Loop:
add X10, X9, X19
cbz X9, endLoop
add X11, X9, X23
ldur X12, [X10, #0]
ldur X13, [X11, #0]
sub X9, X9, 4
add X12, X13, X12
stur X12, [X10, #0]
b Loop
endLoop:

No longer a problem
HAZARD Control freezes appropriate instructions in place by not allowing writes to pipeline registers and zeroes control pipeline registers to create bubble.