Report

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Design

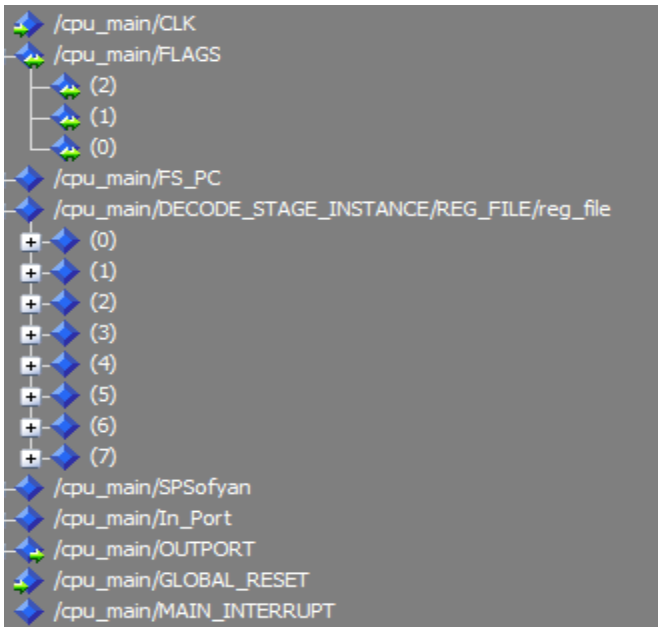
You will find the design file attached and called “Design.pdf”

What is not implemented :

- Branch prediction is designed but not implemented , but we handled it by making stalling .
- Cache memory is not implemented .
- Hazard detection is not working with branch **only , <u>and working with the rest instructions.</u>**
- **<u>Everything else works well.</u>**

Analysis

- The do files and screenshots of all test cases required is given in the report folder (except for cache memory test case).
- To run the test case you will find “IR.txt” and “do file.txt” in every test case folder you should replace the IR in the “project\Pipelined-MIPS” directory with that IR and run the do file .
- The wave form will contain flags , pc , clk , sp , reset , registers(0 -> 7) , Ex:



Where “cpu_main/DECODE_STAGE_INSTANCE/REG_FILE/reg_file” are the registers , and flags(0) -> Z flag , flags(1) -> N flag , flags(2) -> C flag

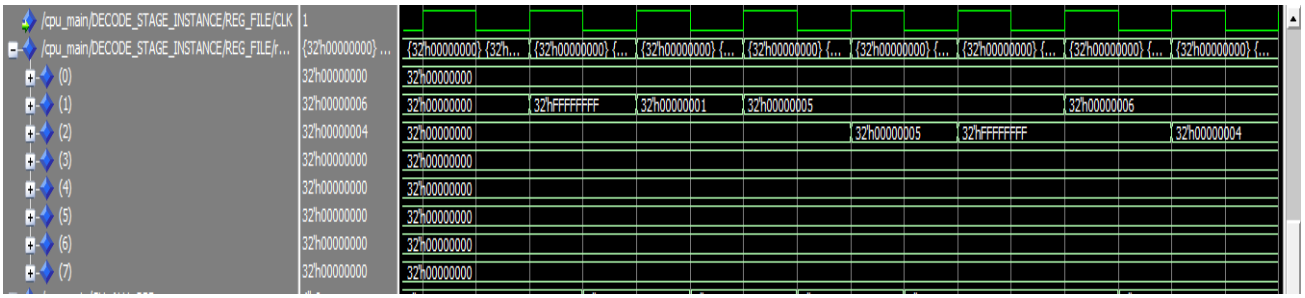
Hazard detection and forwarding Analysis

- Our hazard detection unit stalls 1 cycle when it finds load use case
  Or hazard in (swap , push , STD) instructions
- Our forwarding unit handles hazards without stalling in all instructions except swap , push , std as they are handled in hazard detection unit
- We didn`t handle hazards in branch instructions so we should add 3 NOP operations (software solution) if there was a hazard.
- In branch prediction we designed it however we couldn`t implement it on time so we handled it by stalling .
- An example for hazard handling and forward unit : Given these instructions and the expected with hazard handled outputs using NOP vs hazard outputs

	Correct	Output
NOP	#No change	
NOT R1	#R1 =FFFFFFFF	#R1 =FFFFFFFF
inc R1	#R1 =00000000	#R1 =00000001
in R1	#R1= 5	#R1= 5
in R2	#R2= 5	#R2= 5
NOT R2	#R2= FFFFFFFA	#R2= FFFFFFFF

```
inc R1          #R1= 6                          #R1= 6
Dec R2          #R2  FFFFFFF9                  #R2  = 4
```

Data hazards

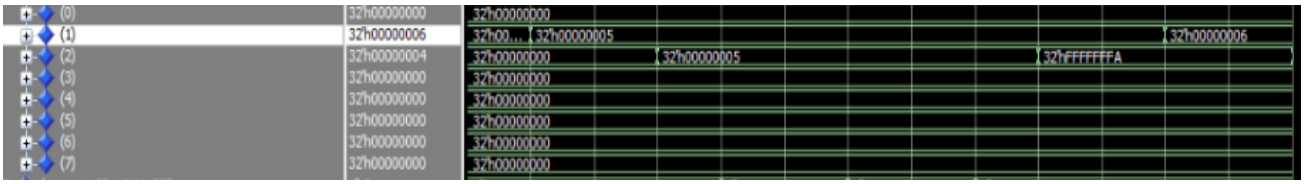


Incorrect outputs

We can solve these hazards using NOP operations where we can change the code to work :

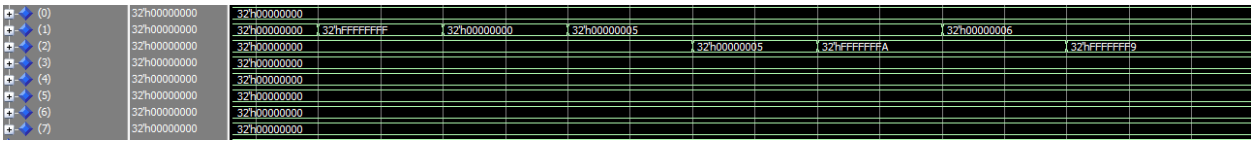
```
NOP             #No change
NOT R1          #R1 =FFFFFFFF
NOP
NOP
inc R1          #R1 =00000000
in R1           #R1= 5
in R2           #R2= 5
NOP
NOP
NOT R2          #R2= FFFFFFFA
inc R1          #R1= 6
NOP
Dec R2          #R2  FFFFFFF9
```

Data hazards



Correct outputs using NOP

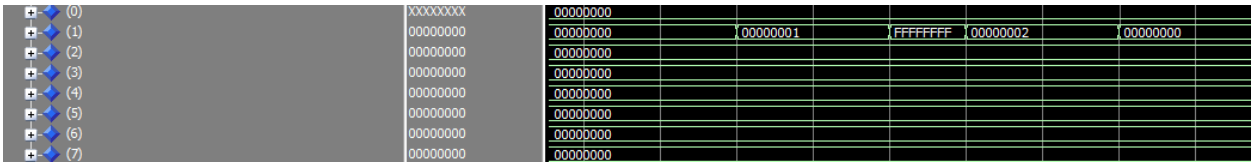
We can also solve these hazards using forward unit where we can forward data without adding NOP



Correct outputs using forward unit and hazard detection

Example 2:

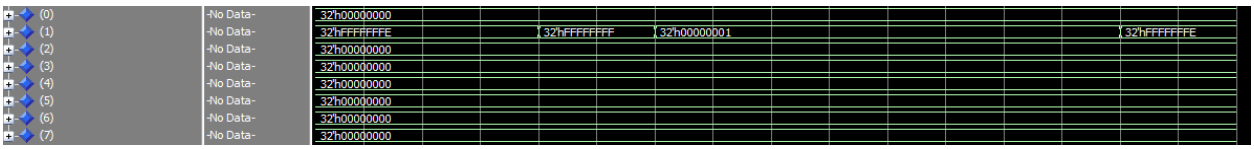
	Correct	Output
inc R1	#R1= 1	#R1= 1
push R1	MEM[4000] = 1	MEM[4000] = 0
NOT R1	#R1 = FFFFFFFFE	#R1= FFFFFFFFF
inc R1	#R1 = FFFFFFFFF	#R1= 2
pop R1	#R1 = 1	#R1= 0 load use case
NOT R1	#R1 = FFFFFFFE	#R1 = 0



Incorrect output due to hazard

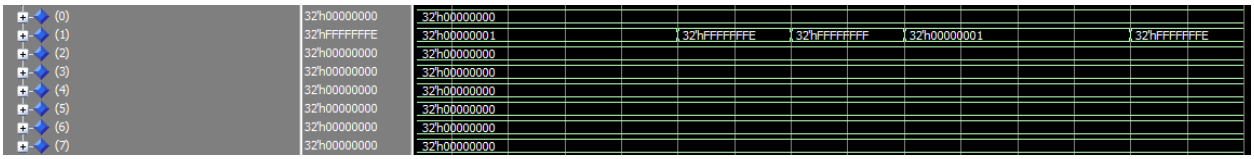
We can also solve these hazards using forward unit where we can forward data without adding NOP

```
inc R1          #R1= 1
NOP
NOP
NOP
push R1         MEM[4000] = 1
NOT R1          #R1 = FFFFFFFFE
NOP
NOP
NOP
inc R1          #R1 = FFFFFFFFF
pop R1          #R1 = 1
NOP
NOP
NOP
NOT R1          #R1 = FFFFFFFE
```



Handling hazards with NOP

We can use Forwarding unit and hazard detection unit to solve hazards without adding NOP



Handling with Forwarding and hazard detection