2022 計算機組織
Computer Organization

Lab 8 Report

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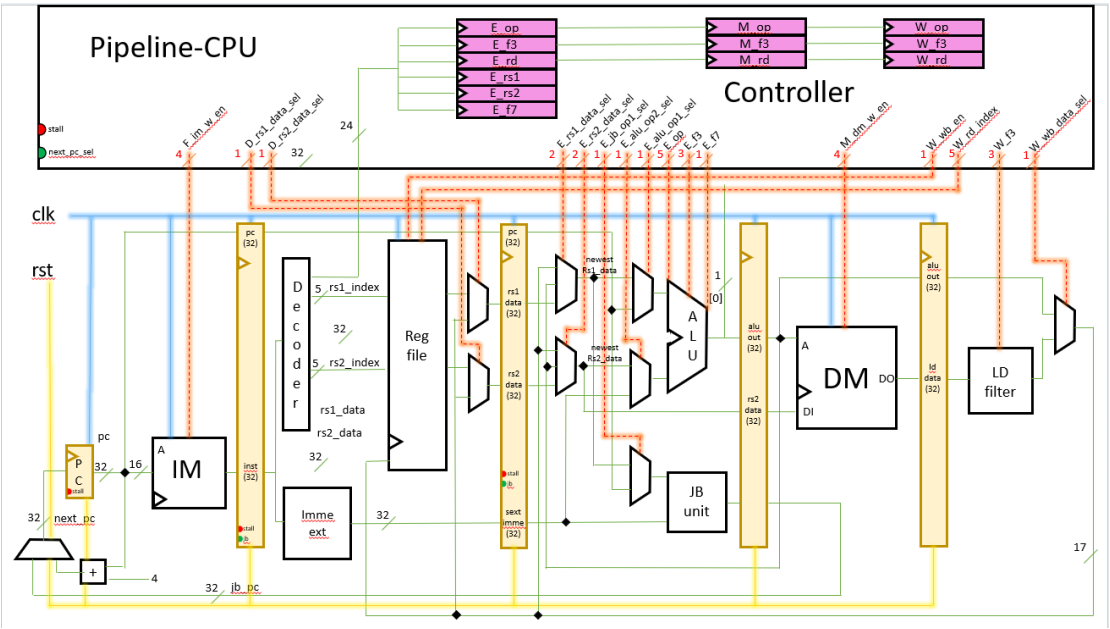
1. Architecture Diagram



2. Explain why Pipeline can accelerate the CPU

原本 single-CPU 的時候，CPU 每次只做一個指令，但當我們變成 pipeline-CPU 的時候，我們能夠把 CPU 切成不同的 part 讓他們個別運作。例如這次實作的是把 CPU 分成 5 個 part，那理論上 CPU 就可以同時處理五個指令，效率就會是五倍，不過還要考慮到一些 hazard & stall & jump misprediction 的問題，所以雖然實際上的效率不會是提升到剛好五倍，不過還是比 single-CPU 的時候提升許多(但架構就比較複雜)。

3. Describe all the hazards you encountered and how you fixed them in your Pipeline CPU

Structure hazard:

這個因為助教在 Lab7 就把 memory 分成 im 跟 dm 兩個，所以這次不會碰到這個問題。

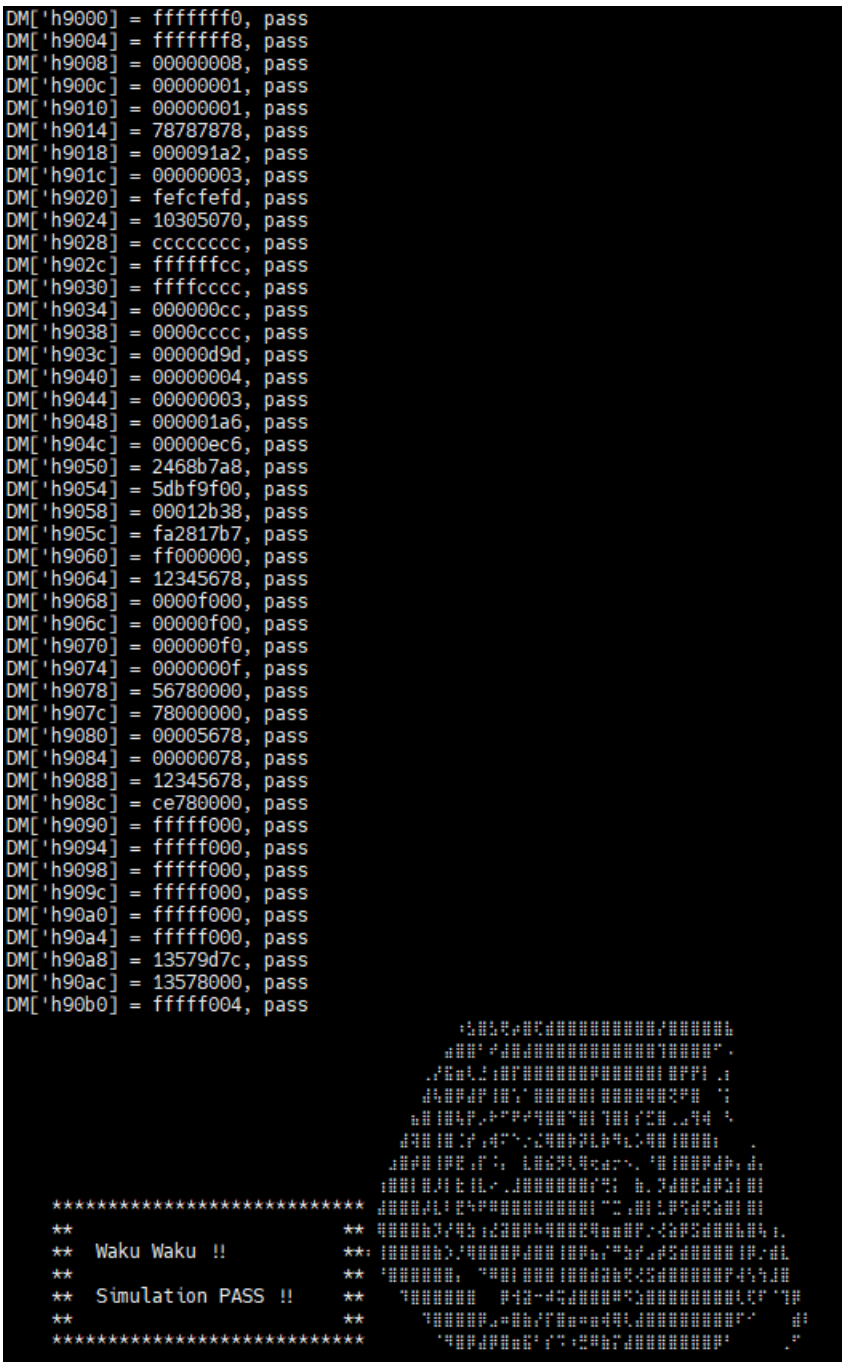
Control hazard:

因為不要讓 pipeline 堵塞(維持效率)，所以採取 branch/jump prediction，也導致了可能出現的 misprediction，解決辦法就是在 Reg_D & Reg_E 加入 jb 的訊號，如果判對 jb == 0 的話，就要把原本錯誤的指令改成 nop，讓電路再回到原本運作模式的同時保證不會因為 misprediction 導致運作到不需要(錯誤)的指令。

Data hazard:

因為同時處理的關係，有時候前面指令還沒運算/儲存完成，就會導致後方的指令執行起來的時候拿到錯誤的值，會發生的地方像是 Stage_E 跟 Stage_M/Stage_D 之間，或是 Stage_W 跟 Stage_D 之間，解決辦法是使用 forwarding 的概念，先去判對前面會不會讀取/使用到後方要更改的 Reg 的值，如果判斷會的話，那就等後方成功運算好後的值取代掉前面拿錯的，如此就能確保前面拿到的是正確的值。

4. Screenshot the successful result of prog0



5. Screenshot the successful result of prog1

```
DM['h9000] = 00000000, pass
DM['h9004] = 00000001, pass
DM['h9008] = 00000001, pass
DM['h900c] = 00000003, pass
DM['h9010] = 00000003, pass
DM['h9014] = 00000006, pass
DM['h9018] = 00000008, pass
DM['h901c] = 0000000a, pass
DM['h9020] = 0000000a, pass
DM['h9024] = 0000000b, pass
DM['h9028] = 0000000c, pass
DM['h902c] = 0000000f, pass
DM['h9030] = 00000010, pass
DM['h9034] = 00000012, pass
DM['h9038] = 00000012, pass
DM['h903c] = 00000017, pass
DM['h9040] = 00000017, pass
DM['h9044] = 00000017, pass
DM['h9048] = 00000018, pass
DM['h904c] = 0000001b, pass
DM['h9050] = 0000001e, pass
DM['h9054] = 00000025, pass
DM['h9058] = 00000025, pass
DM['h905c] = 00000026, pass
DM['h9060] = 00000027, pass
DM['h9064] = 00000028, pass
DM['h9068] = 00000028, pass
DM['h906c] = 00000029, pass
DM['h9070] = 0000002b, pass
DM['h9074] = 0000002d, pass
DM['h9078] = 0000002d, pass
DM['h907c] = 0000002e, pass
DM['h9080] = 0000002f, pass
DM['h9084] = 00000031, pass
DM['h9088] = fffffce, pass
DM['h908c] = fffffce, pass
DM['h9090] = fffffd1, pass
DM['h9094] = fffffd1, pass
DM['h9098] = fffffd2, pass
DM['h909c] = fffffe2, pass
DM['h90a0] = fffffe9, pass
DM['h90a4] = fffffea, pass
DM['h90a8] = fffffeb, pass
DM['h90ac] = fffffed, pass
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```
DM['h90b0] = fffffffef, pass
DM['h90b4] = fffffff3, pass
DM['h90b8] = fffffff7, pass
DM['h90bc] = fffffffa, pass
DM['h90c0] = fffffffa, pass
DM['h90c4] = fffffffd, pass
DM['h90c8] = fffffffe, pass
DM['h90cc] = ffffffff, pass
DM['h90d0] = 00000000, pass
DM['h90d4] = ffffffcf, pass
DM['h90d8] = ffffffd2, pass
DM['h90dc] = ffffffd2, pass
DM['h90e0] = ffffffd4, pass
DM['h90e4] = ffffffd5, pass
DM['h90e8] = ffffffd6, pass
DM['h90ec] = ffffffdb, pass
DM['h90f0] = ffffffe3, pass
DM['h90f4] = ffffffe3, pass
DM['h90f8] = ffffffe8, pass
DM['h90fc] = ffffffe9, pass
DM['h9100] = fffffffee, pass
DM['h9104] = fffffffee, pass
DM['h9108] = fffffffee, pass
DM['h910c] = fffffffef, pass
DM['h9110] = fffffff0, pass
DM['h9114] = fffffffe, pass
DM['h9118] = 00000000, pass
DM['h911c] = 00000000, pass
DM['h9120] = 00000000, pass
DM['h9124] = 00000003, pass
DM['h9128] = 00000009, pass
DM['h912c] = 0000000f, pass
DM['h9130] = 00000013, pass
DM['h9134] = 00000016, pass
DM['h9138] = 00000017, pass
DM['h913c] = 00000017, pass
DM['h9140] = 00000023, pass
DM['h9144] = 0000002e, pass
```