SoC Final Project

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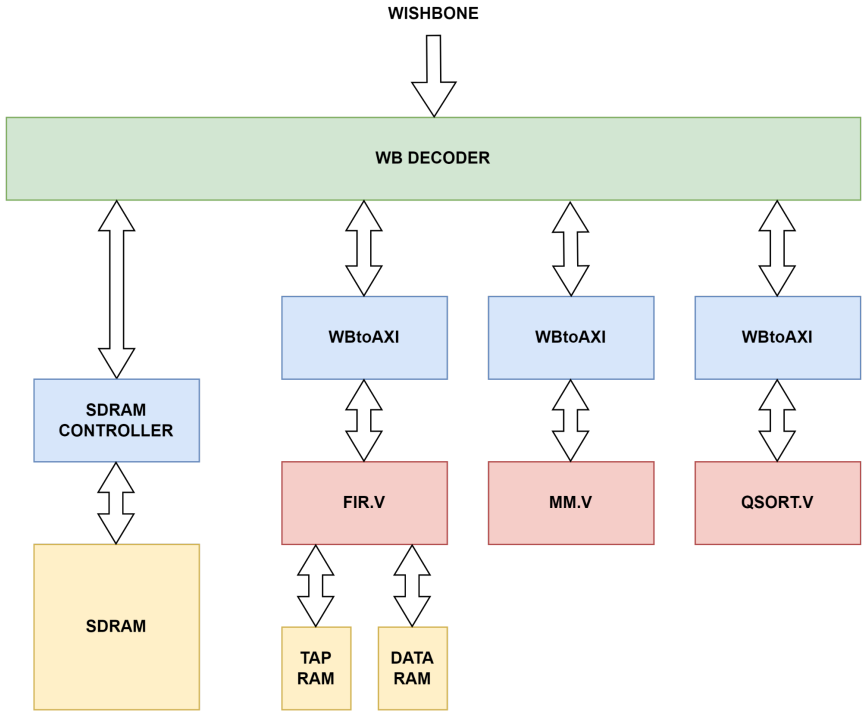
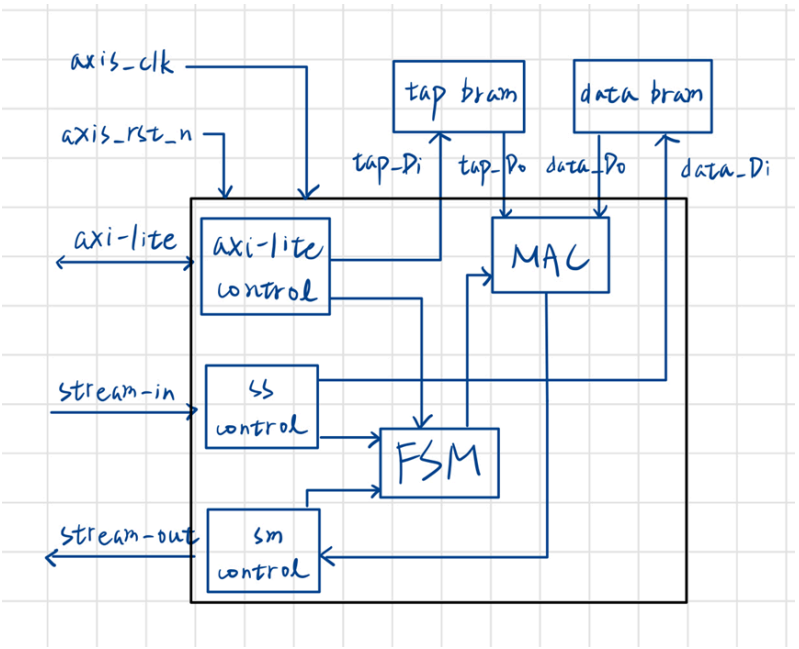
1. Block Diagram of System



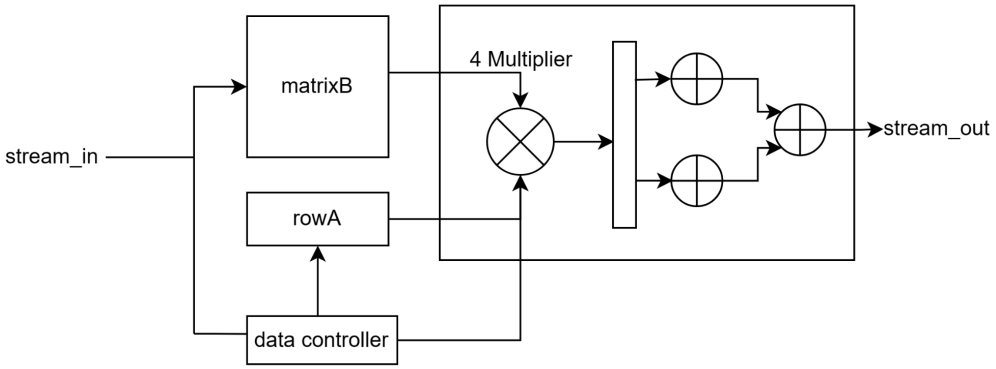
2. Bottleneck of baseline design & Optimize directions
   我們使用 Lab6的 design作為我們的 Baseline design，但由於原先的 design 是使用 fireware code 來進行 quick sort, matrix multiplier, fir 的運算，要使用乘法運算時 CPU 會一直 jump 進乘法的 instruction code，產生多餘的 instructions

   Optimize directions:
   - Hardware accelerator
     - qsort
     - mm
     - fir
   - SDRAM prefetch
   - Firmware optimization

3. Hardware FIR
   Block Diagram:

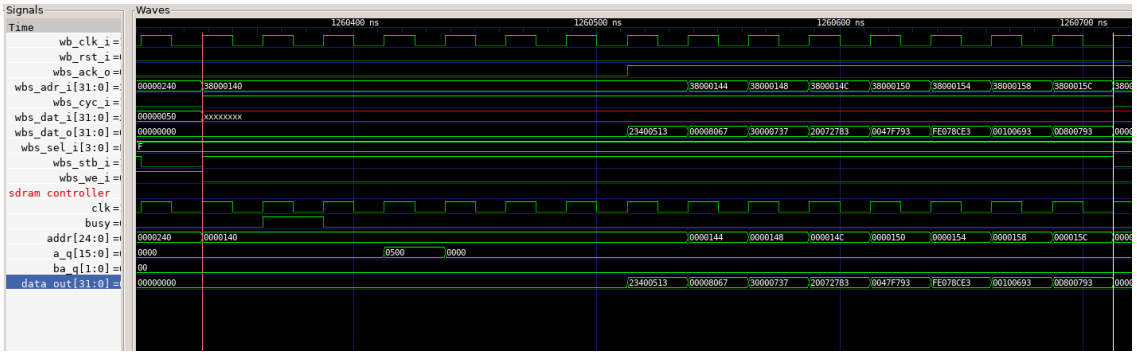


4. Hardware MatMul
   Block Diagram:



首先透過 axi-stream interface 將 data 吃進來，並先把 matrixB 的16個值都先存在 buffer 內，接著每讀完一個 matrixA 的 Row 後進行乘加運算，總共使用4個乘法器與3個加法器，最後一樣透過 axi-stream interface 輸出答案。

5. Sdram prefetch & burst



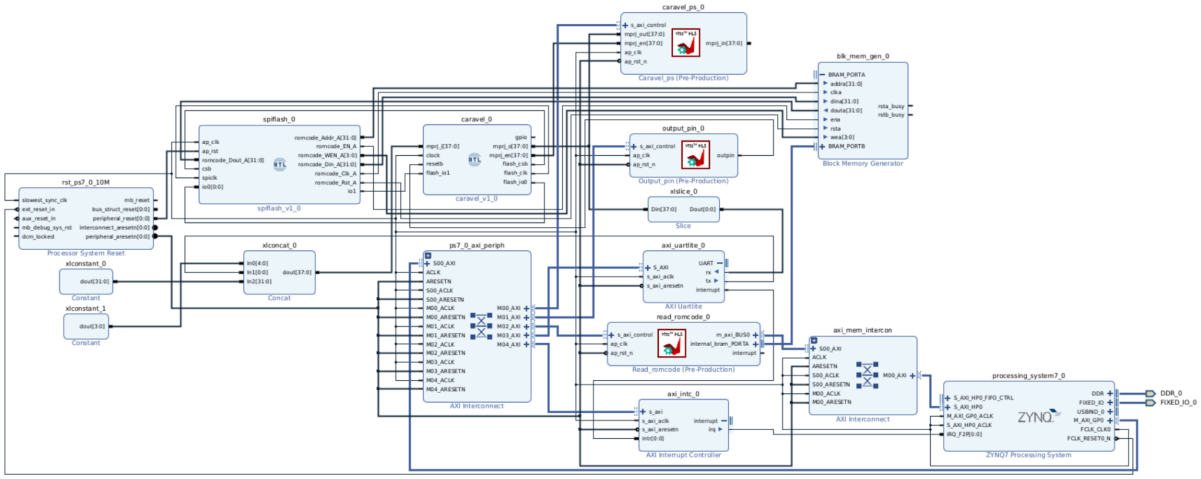
6. Results

	origin	with O2	hardware accelerator + sdram	hardware accelerator + sdram with O2	improvement
QSORT	37961	6182	29896	4034	9.41x
MM	69033	13597	17075	3697	18.67x
FIR	72120(4-2)	40548	40082	4983	14.47x

7. Address mapping

FIR	FIR_CTRL	0x30000000
	DATALENGTH	0x30000010
	TAP	0x30000040
	Xn	0x30000080
	Yn	0x30000084
MM	MM_CTRL	0x30000100
	arrA	0x30000180
	arrB	0x30000184
	arrR	0x3000018c
QSORT	QSORT_CTRL	0x30000200
	QSORT_IN	0x30000280
	QSORT_OUT	0x30000284

8. Block design of FPGA



9. Timing report

Design Timing Summary

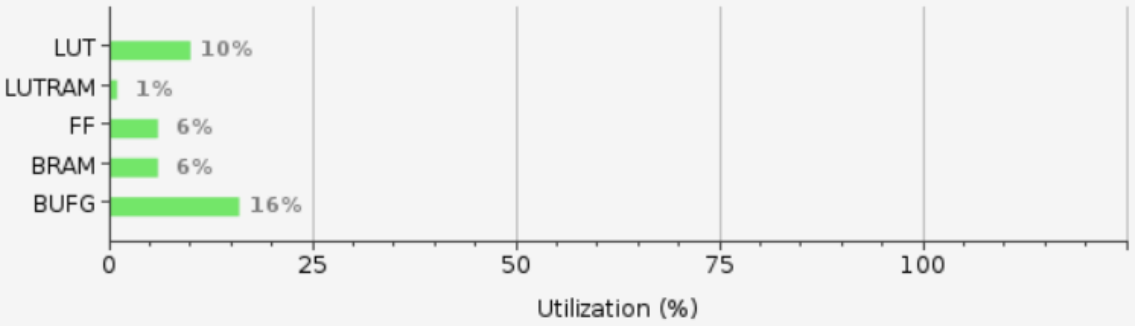
Setup		Hold		Pulse Width	
Worst Negative Slack (WNS):	9.054 ns	Worst Hold Slack (WHS):	0.026 ns	Worst Pulse Width Slack (WPWS):	11.250 ns
Total Negative Slack (TNS):	0.000 ns	Total Hold Slack (THS):	0.000 ns	Total Pulse Width Negative Slack (TPWS):	0.000 ns
Number of Failing Endpoints:	0	Number of Failing Endpoints:	0	Number of Failing Endpoints:	0
Total Number of Endpoints:	12807	Total Number of Endpoints:	12807	Total Number of Endpoints:	5301

All user specified timing constraints are met.

10. Resource report

Utilization Post-Synthesis | **Post-Implementation**

Graph | Table



Resource	Utilization	Available	Utilization %
LUT	5362	53200	10.08
LUTRAM	188	17400	1.08
FF	6195	106400	5.82
BRAM	8	140	5.71
BUFG	5	32	15.63

11. Jupyter Notebook

```
asyncio.run(async_main())
```

```
Start Caravel Soc
Waitting for interrupt
matmul start
matmul end
qs start
qs end
fir start
fir end
hello
main(): uart_rx is cancelled now
```

```
print ("0x10 = ", hex(ipPS.read(0x10)))
print ("0x14 = ", hex(ipPS.read(0x14)))
print ("0x1c = ", hex(ipPS.read(0x1c)))
print ("0x20 = ", hex(ipPS.read(0x20)))
print ("0x34 = ", hex(ipPS.read(0x34)))
print ("0x38 = ", hex(ipPS.read(0x38)))
```

```
0x10 =  0x0
0x14 =  0x0
0x1c =  0xab510040
0x20 =  0x0
0x34 =  0x20
0x38 =  0x3f
```