

Assignment 5

Wei Liu
weiliu@cs.utah.edu

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Question 1

The IPC for each benchmark is:

```
weiliu@wukong:~/coursework/ca/hw5/cs6810> grep "IPC is" *out
craftyout:IPC is - 1.358
mesaout:IPC is - 2.066
mgridout:IPC is - 0.698
parserout:IPC is - 0.620
```

the harmonic mean of IPC is 0.9377.

The power consumption for each benchmark is:

```
weiliu@wukong:~/coursework/ca/hw5/cs6810> grep "Power consumption is" *out
craftyout:Power consumption is - 54.915 Watts
mesaout:Power consumption is - 68.233 Watts
mgridout:Power consumption is - 62.375 Watts
parserout:Power consumption is - 47.656 Watts
```

the arithmetic mean of power consumption is 58.295.

Changed the LSQ to 80, repeat the experiment. The IPC for each benchmark is:

```
weiliu@wukong:~/coursework/ca/hw5/cs6810> grep "IPC is" *out
craftyout:IPC is - 1.359
mesaout:IPC is - 2.083
mgridout:IPC is - 0.698
parserout:IPC is - 0.620
```

the harmonic mean of IPC is 0.9386.

The power consumption for each benchmark is:

```
weiliu@wukong:~/coursework/ca/hw5/cs6810> grep "Power consumption is" *out
craftyout:Power consumption is - 55.416 Watts
mesaout:Power consumption is - 69.142 Watts
mgridout:Power consumption is - 62.692 Watts
parserout:Power consumption is - 47.973 Watts
```

the arithmetic mean of power consumption is 58.806.

Changed the LSQ to 160, and repeat the experiment. The IPC for each benchmark is:

```
weiliu@wukong:~/coursework/ca/hw5/cs6810> grep "IPC is" *out
craftyout:IPC is - 1.359
mesaout:IPC is - 2.083
mgridout:IPC is - 0.698
parserout:IPC is - 0.620
```

the harmonic mean of IPC is 0.9386, same with the IPC when LSQ is 80.

The power consumption for each benchmark is:

```
weiliu@wukong:~/coursework/ca/hw5/cs6810> grep "Power consumption is" *out
craftyout:Power consumption is - 56.385 Watts
mesaout:Power consumption is - 70.226 Watts
mgridout:Power consumption is - 63.327 Watts
parserout:Power consumption is - 48.566 Watts
```

the arithmetic mean of power consumption is 59.626.

There are various reasons that the performance does not improve much. First, load/store instructions are probably only small part in the benchmarks. So from Amdahl law, the improvement of this small part, even is big, still barely have impact on the performance improvement of whole system. Second, even LSQ is the bottleneck of performance, only increasing LSQ size can not guarantee the performance improvement. The out-of-order buffer may have small band width, or .the load instruction stil wait long time for the store instr. solve the addresses.

Question 2

Choose the various combinations of the capacity of the direction predictors as follows:

	N	W	M	Bimodal Pred	Bimodal Association	Selector	Sum
round 1	256	4	256	64k	2	1k	130k
round 2	2k	13	8k	32k	2	8k	122k
round 3	1	15	32k	16k	2	16k	128k

The IPC and miss prediction rate is as follows(The table gave gave the prediction rate, so the actual 'mis-predicion' rate is $1 - predictionrate$).

	crafty.IPC	crafty miss	parser.IPC	parser miss	mesa.IPC	mesa miss	HM.IPC	AM miss
Round one	1.413	0.9227	0.629	0.9216	2.190	0.9558	1.089	0.933
Round two	1.439	0.9293	0.635	0.9275	2.219	0.9657	1.103	0.941
Round three	1.404	0.9233	0.626	0.9223	2.153	0.9488	1.081	0.932
Default	1.358	0.9027	0.620	0.9156	2.066	0.9293	1.059	0.916

we compare the second round with the default configuration. The second round has mis-prediction rate 0.059. So compared with the default configuration, the mis-prediction rate decreased by 30%. The IPC accordingly increased 4.15%.

question 3

Increase to 2X

Change all the following to x2: branch predictor, BTB, RUU (ROB), LSQ, L1 data cache, L1 instr cache. And Get the IPCs:

```
weiliu@wukong:~/coursework/ca/hw5/cs6810> grep "IPC is" *out
craftyout:IPC is - 1.616
mesaout:IPC is - 2.336
mgridout:IPC is - 1.171
parserout:IPC is - 0.633
```

The HM of the IPC is 1.149.

The default IPC, as I tested in the question 1, is as follows:

```
weiliu@wukong:~/coursework/ca/hw5/cs6810> grep "IPC is" *out
craftyout:IPC is - 1.358
mesaout:IPC is - 2.066
mgridout:IPC is - 0.698
parserout:IPC is - 0.620
```

And the harmonic mean of IPC in default configuraiton is 0.9377. To get the clock cycle time reduction allowed when new configuration has same performance with old one,

$$Speedup = \frac{ClockCycleTime_{old} \cdot CPI_{old} \cdot No.of Instr_{old}}{ClockCycleTime_{new} \cdot CPI_{new} \cdot No.of Instr_{new}} = 1 \quad (1)$$

As the number of instructions are same in old and new configurations, we have

$$\frac{ClockSpeed_{new}}{ClockSpeed_{old}} = \frac{ClockCycleTime_{old}}{ClockCycleTime_{new}} = \frac{CPI_{new}}{CPI_{old}} = \frac{IPC_{old}}{IPC_{new}} = \frac{0.9377}{1.149} = 0.816 \quad (2)$$

so the reduction that can be tolerated is $1 - 0.816 = 18.4\%$

Increase to 4x

If everything increase to 4x, then the IPC is:

```
craftyout:IPC is - 1.696
mesaout:IPC is - 2.392
mgridout:IPC is - 1.310
parserout:IPC is - 0.642
```

The harmonic mean at this time is 1.202. And similiary, the reduction that can be tolerated is $1 - \frac{0.9377}{1.202} = 0.220 = 22\%$

Question 4

construct a L1 and L2 combination under the 2M constraint. The latency is computed based on the default a.cfg, and rounded to the integer.

	sets	Line Size	Associativity	Capacity	Latency	
Round 1(Mid-size)	L1	1k	32	4	128k	4
	L2	2k	64	15	1920k	16
Round 2 (Big L2, small L1)	L1	256	32	2	16k	1
	L2	4k	32	15	2032k	12
Round 3 (Bigger L1, smaller L2)	L1	2k	32	8	512k	8
	L2	4k	32	12	1536k	16
default	L1	512	32	2	32k	2
	L2	4k	64	8	2M	16

the simulation result on the first round is:

```
weiliu@wukong:~/coursework/ca/hw5/cs6810> grep "IPC is" *out
craftyout:IPC is - 1.344
mesaout:IPC is - 2.023
mgridout:IPC is - 0.693
parserout:IPC is - 0.605
```

The Harmonic mean of IPC is 0.923.

The simulation result on the second round:

```
weiliu@wukong:~/coursework/ca/hw5/cs6810> grep "IPC is" *out
craftyout:IPC is - 1.401
mesaout:IPC is - 2.054
mgridout:IPC is - 0.420
parserout:IPC is - 0.435
```

The Harmonic mean of IPC is 0.680.

the simulation result on the third round:

```
craftyout:IPC is - 1.220
mesaout:IPC is - 1.802
mgridout:IPC is - 0.407
parserout:IPC is - 0.394
```

The Harmonic mean of IPC is 0.628.

All the three rounds of test have lower performance than default configuration, which has CPI 0.9377.