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CS2410 Project #1 Report

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**Comparative Analysis**

**Setup 1:**

Limiting the issuing and commits of instructions has a bad but negligible effect on the cycle count, and accordingly the IPC tends to decrease by a small amount. The program cycle counts only increase by a few instructions, with program 5 actually having the same cycle count, compared with the default. This suggests that, rather than structural hazards preventing the execution of instructions, data hazards present in the programs are the more significant bottleneck causing stalls. Programs with fewer close data dependencies may have experienced greater penalties in performance.

Since the sizes of the reservation stations and the ROB did not change, but the throughput of instructions was reduced, we see that fewer stalls occurred from instructions trying to enter the reservation stations or the ROB. Despite this slight reduction in structural hazards, the cycle count still increased from the data dependencies discussed above.

**Setup 2:**

Overall, this setup exhibited a somewhat larger increase in the cycle count than that which occurred in Setup 1. Despite the fetching and decoding being limited, it seems that the largest bottleneck in this setup was the reduction of the ROB size from 16 to 4. We can see in the last chart that the number of stalls of instructions trying to enter the ROB spiked very significantly from the default setup, while the number of stalls caused by the reservations dropped to almost none. However, reducing the throughput of instructions entering the pipeline probably also contributed to the increase in number of cycles and the corresponding decrease in IPC. Program 5, strangely, has a slight reduction in cycle count, a reason for which is hypothesized in the analysis of Setup 3.

**Setup 3:**

Overall, this setup exhibited some increases in the cycle count, although program 5 is an outlier in having a greatly decreased cycle count even though the ROB size was halved. Program 5 reveals a complex situation where, when the ROB is large (like in the default scenario) and instructions can be freely assigned to it, the reservation station quickly becomes a bottleneck that stalls the in-order issue of instructions, and the penalty for branching increases because more instructions have been issued that need to cycle through the execution units before being flushed (at least in our implementation, instructions that were issued complete even if they are marked for flushing in the ROB).

If a reservation station gets filled for an execution unit that takes many cycles or contains instructions waiting on data, it will stall the issue of instructions until one of the instructions commits. With a large ROB, instructions can be freely issued until a reservation station is full, which will happen quickly, but then the issue of instructions will also be quickly blocked. Something to do with the organization of instructions using the same execution unit caused the overall number of structural stalls to decrease slightly in this scenario for program 5, while in others the number of structural stalls increased.

**Cycles**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Benchmarks | 1 | 2 | 3 | 4 | 5 |
| Default | 53 | 111 | 78 | 73 | 139 |
| 1. NW=NB=NC=2 | 56 | 113 | 80 | 78 | 139 |
| 2. NF=ND=2,NQ=NI=4, NW=NR=NC=4 | 63 | 143 | 90 | 101 | 127 |
| 3. NW=NB=NC=NF= ND=4, NQ=NI=8, NR=8 | 54 | 116 | 78 | 88 | 106 |

**IPC**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Benchmarks | 1 | 2 | 3 | 4 | 5 |
| Default | 0.5094 | 0.7477 | 0.5 | 0.7534 | 0.3819 |
| 1. NW=NB=NC=2 | 0.4821 | 0.7345 | 0.4875 | 0.7051 | 0.3819 |
| 2. NF=ND=2,NQ=NI=4, NW=NR=NC=4 | 0.4285 | 0.5804 | 0.4333 | 0.5445 | 0.4173 |
| 3. NW=NB=NC=NF= ND=4, NQ=NI=8, NR=8 | 0.5 | 0.7155 | 0.5 | 0.625 | 0.5 |

**Stalls due to reservation stations**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Benchmarks | 1 | 2 | 3 | 4 | 5 |
| Default | 26 | 74 | 39 | 16 | 85 |
| 1. NW=NB=NC=2 | 20 | 53 | 28 | 11 | 70 |
| 2. NF=ND=2,NQ=NI=4, NW=NR=NC=4 | 0 | 3 | 0 | 1 | 1 |
| 3. NW=NB=NC=NF= ND=4, NQ=NI=8, NR=8 | 0 | 5 | 0 | 2 | 3 |

**Stalls due to ROB**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Benchmarks | 1 | 2 | 3 | 4 | 5 |
| Default | 0 | 0 | 0 | 27 | 11 |
| 1. NW=NB=NC=2 | 0 | 0 | 0 | 17 | 8 |
| 2. NF=ND=2,NQ=NI=4, NW=NR=NC=4 | 49 | 126 | 68 | 85 | 104 |
| 3. NW=NB=NC=NF= ND=4, NQ=NI=8, NR=8 | 30 | 86 | 60 | 68 | 81 |