2019 Spring NCTU Computer Organization

Lab5 Report

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1 Memory Stall Cycles Calculations

Notions	Operations	Delay (cycle)
t_{sa}	Send the address	1
t_{al}	Access single cache content	2
t_{al1}	Access L1 cache content	1
t_{al2}	Access L2 cache content	10
t_{am}	Access memory content	100
t_{sw}	Send a word of data	1

1.1 One-word-wide memory organization

$$\begin{aligned} hit\_cycles &= t_{sa} + t_{al} + t_{sw} \\ &= 1 + 2 + 1 = 4 \\ miss\_cycles &= t_{sa} + 8 \times (t_{sa} + t_{am} + t_{sw} + t_{al}) + t_{al} + t_{sw} \\ &= 1 + 8 \times (1 + 100 + 1 + 2) + 2 + 1 = 836 \end{aligned}$$

1.2 Wider memory organization

$$\begin{aligned} hit\_cycles &= t_{sa} + t_{al} + t_{sw} \\ &= 1 + 2 + 1 = 4 \\ miss\_cycles &= t_{sa} + (t_{sa} + t_{am} + t_{sw} + t_{al}) + t_{al} + t_{sw} \\ &= 1 + (1 + 100 + 1 + 2) + 2 + 1 = 108 \end{aligned}$$

1.3 Two-level memory organization

$$\begin{aligned} hit\_cycles &= t_{sa} + t_{al1} + t_{sw} \\ &= 1 + 1 + 1 = 3 \\ L1\_miss\_cycles &= t_{sa} + (t_{sa} + t_{al2} + t_{sw} + t_{al1}) + t_{al1} + t_{sw} \\ &= 1 + 4 \times (1 + 10 + 1 + 1) + 1 + 1 = 55 \\ global\_miss\_cycles &= t_{sa} + 32 \times (t_{sa} + t_{am} + t_{sw} + t_{al2}) + 4 \times (t_{sa} + t_{al2} + t_{sw} + t_{al1}) + t_{al1} + t_{sw} \\ &= 1 + 32 \times (1 + 100 + 1 + 10) + 4 \times (1 + 10 + 1 + 1) + 1 + 1 = 3639 \end{aligned}$$

2 Differences among Memory Organizations

3 Bonus

3.1 matmul.txt

```
for (i = 0; i < m; i ++) {
    for (j = 0; j < p; j ++) {
        for (k = 0; k < n; k ++) {
            load C[i][j];
            load A[i][k];
            load B[k][j];
            do C[i][j] += A[i][k] * B[k][j];
            store C[i][j];
        }
    }
}
```

3.2 bonus.txt

```
for (i = 0; i < m; i ++) {
    for (j = 0; j < n; j ++) {
        load A[i][j];
        for (k = 0; k < p; k ++) {
            load C[i][k];
            load B[j][k];
            do C[i][k] += A[i][j] * B[j][k];
            store C[i][k];
        }
    }
}
```