Lecture 27

Associative Caches

Review

1. Sets (S)

2. Cache Lines (E)

3. Cache block size (B)

Cache size (C) = S x E x B
Direct mapped caches

```
E = 1
```

Issue

```
x 0 1 2 3 x 0 1 2 3
```

```python
for (i = 0; i < 4; i++)
    sum += a[i] * b[i]
```
<table>
<thead>
<tr>
<th>(x[0])</th>
<th>0</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(y[0])</th>
<th>24</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28</td>
<td>1</td>
</tr>
</tbody>
</table>

Wasted.

Set Associative Caches

<table>
<thead>
<tr>
<th>So</th>
</tr>
</thead>
<tbody>
<tr>
<td>(x_0, x_1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Si</th>
</tr>
</thead>
<tbody>
<tr>
<td>(y_0, y_1)</td>
</tr>
</tbody>
</table>

\(E = 2\)
1. Set selection.
   \[ \frac{C}{B} < E < \frac{C}{B} \]
   \[ C = S \times E \times B \]
   \[ \frac{B}{B} \]
   \[ E \leq S \times E \]
   \[ \Rightarrow S > 1 \]

2. Line matching and block selection.

   \[ Si \]
   \[ \text{selected set} \]

   1. Search the tag.
   2. valid == 1
3. **Line replacement on Misses**

Replacement policy:
1. Random.
2. Least Freq. used.
3. Least Recently used.

[Diagram of line replacement with valid tags and blocks b₁ and b₂ marked with numbers 5 and 2 respectively.]
Fully Associative Cache
"Small caches"

\[ S = 1 \]

\[ E = \frac{C}{B} \]