Practice HW Cache Problem

December 8, 2016

1. We’re given a memory system with the following properties:
   - Memory is byte addressable and is accessible in 1-byte words (not 4-byte words)
   - Physical addresses are 13 bits wide
   - The cache is 4-way set associative
   - Cache lines are 4 bytes
   - There are 16 lines

   (a) Which bit(s) of a 13-bit address are used for:
   i. (1 point) Offset within a cache line
      - 2 bits
   ii. (1 point) Set index
      - 2 bits
   iii. (1 point) Cache tag
      - 9 bits

Solution:
   - Lines are 4 bytes, so we need 2 bits for offset.
   - There are 4 sets, so we need 2 bits to specify the set
   - This leaves 9 of the 13 bits for tag.
(b) Suppose that we attempt to access address 0x0E34

i. (1 point) What is the address in binary?

**Solution:** 0 1110 0011 0100

which means

<table>
<thead>
<tr>
<th>tag</th>
<th>set</th>
<th>offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>01110 0011</td>
<td>01</td>
<td>00</td>
</tr>
</tbody>
</table>

ii. (1 point) In what set would the block be found if it were in the cache?

ii. \(01 \equiv 1\)

iii. (1 point) What is the cache tag?

iii. \(0 1110 0011 = 0x0E3\)

iv. (1 point) Is it a cache hit? A. yes   B. no

**Solution:** In set 1, do we find the tag 0x0E3 with a valid bit of 1? No.

v. (1 point) What is the byte returned?

v. None. It was a cache miss

**Solution:** Because it was a cache miss, we would go off to the next lower level of storage, read from address 0x0E3, copy it to the cache, evicting some other block in the process.
(c) Suppose that we attempt to access address 0x1913?
   i. (1 point) What is the address in binary?

   \[
   \textbf{Solution: } 11001 0001 0011
   \]
   which means

   \[
   \begin{array}{cccc}
   \text{tag} & \text{set} & \text{offset} \\
   11001 0001 & 00 & 11 \\
   \end{array}
   \]

   ii. (1 point) In what set would the block be found if it were in the cache?

   \[
   \text{ii. } 00_2 = 0_{10}
   \]

   iii. (1 point) What is the cache tag?

   \[
   \text{iii. } 11001 0001_2 = 0x191
   \]

   iv. (1 point) Is it a cache hit?  \textbf{A. yes}  \textbf{B. no}

   \[
   \textbf{Solution: } \text{In set 0, do we find the tag 0x191 with a valid bit of 1? Yes.}
   \]

   v. (1 point) What is the byte returned?

   \[
   \text{v. } 0xCE \ (\text{offset } 3)
   \]