CSC 315

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Cuckoo Hashing

Consider the following cuckoo hashing schema:

1. Both tables have a size of 4.
2. The hashing function of the first table returns the fourth and third least significant bits: $h_1(x) = (x >> 2)$ & 0b11.
3. The hashing function of the second table returns the least significant two bits: $h_2(x) = x$ & 0b11.
4. When inserting, try table 1 first.
5. When replacement is necessary, first select an element in the second table.
6. The original entries in the table are shown in the figure below.

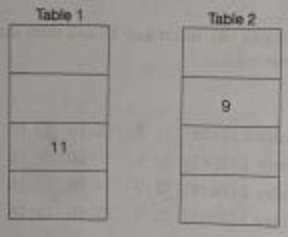

Figure 1: Initial contents of the hash tables.

(a) **[1 point]** Select the sequence of insert operations that results in the initial state.
(●) Insert 11, insert 9 ☐ Insert 9, insert 11 ☐ None of the above

(b) Insert key 16 and then delete 11. Select the value in each entry of the resulting two tables.

i. Table 1

α) **[1 point]** Entry 0 (0b00) ☑ 16 ☐ 9 ☐ Empty

β) **[1 point]** Entry 1 (0b01) ☐ 16 ☐ 9 ☑ Empty

γ) **[1 point]** Entry 2 (0b10) ☐ 16 ☐ 9 ☑ Empty

δ) **[1 point]** Entry 3 (0b11) ☐ 16 ☐ 9 ☑ Empty

ii. Table 2

α) **[1 point]** Entry 0 (0b00) ☐ 16 ☐ 9 ☑ Empty

β) **[1 point]** Entry 1 (0b01) ☐ 16 ☑ 9 ☐ Empty

γ) **[1 point]** Entry 2 (0b10) ☐ 16 ☐ 9 ☑ Empty

δ) **[1 point]** Entry 3 (0b11) ☐ 16 ☐ 9 ☑ Empty

(c) After the changes from part **(b)**, insert key 17 and then insert 10 .Select the value in each entry of the resulting two tables.

i. Table 1

α) **[1 point]** Entry 0 (0b00) ☐ 9 ☐ 10 ☑ 16 ☐ 17 ☐ Empty

β) **[1 point]** Entry 1 (0b01) ☑ 9 ☐ 10 ☐ 16 ☐ 17 ☑ Empty

γ) **[1 point]** Entry 2 (0b10) ☑ 9 ☐ 10 ☐ 16 ☐ 17 ☐ Empty

δ) **[1 point]** Entry 3 (0b11) ☐ 9 ☐ 10 ☐ 16 ☐ 17 ☑ Empty

ii. Table 2

α) **[1 point]** Entry 0 (0b00) ☐ 9 ☐ 10 ☐ 16 ☐ 17 ☑ Empty

β) **[1 point]** Entry 1 (0b01) ☐ 9 ☐ 10 ☐ 16 ☑ 17 ☐ Empty

γ) **[1 point]** Entry 2 (0b10) ☐ 9 ☑ 10 ☐ 16 ☐ 17 ☐ Empty

δ) **[1 point]** Entry 3 (0b11) ☐ 9 ☐ 10 ☐ 16 ☐ 17 ☑ Empty

After the changes from parts **(b)** and **(c)**, insert key 33 and then delete 16. Select the value in each entry of the resulting two tables.

i. Table 1

α) **[1 point]** Entry 0 (`0b00`) ☐ 9 ☐ 10 ◉ 17 ☐ 33 ☐ Empty

β) **[1 point]** Entry 1 (`0b01`) ☐ 9 ☐ 10 ☐ 17 ☐ 33 ◉ Empty

γ) **[1 point]** Entry 2 (`0b10`) ◉ 9 ☐ 10 ☐ 17 ☐ 33 ☐ Empty

δ) **[1 point]** Entry 3 (`0b11`) ☐ 9 ☐ 10 ☐ 17 ☐ 33 ◉ Empty

ii. Table 2

α) **[1 point]** Entry 0 (`0b00`) ☐ 9 ☐ 10 ☐ 17 ☐ 33 ◉ Empty

β) **[1 point]** Entry 1 (`0b01`) ☐ 9 ☐ 10 ☐ 17 ◉ 33 ☐ Empty

γ) **[1 point]** Entry 2 (`0b10`) ☐ 9 ◉ 10 ☐ 17 ☐ 33 ☐ Empty

δ) **[1 point]** Entry 3 (`0b11`) ☐ 9 ☐ 10 ☐ 17 ☐ 33 ◉ Empty

(e) **[5 points]** What is the smallest key that potentially causes an infinite loop given the table that results from part **(d)**?

☐ 17 ☐ 33 ☐ 3 ◉ 1 ☐ 37 ☐ 51 ☐ None of the above