Quadratic Hashing

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Let $h_1(k,M) = k\%M$

Examples of quadratic functions:

1) $h(k,i,M) = (h_1(k,M) + 2i + i^2)\%M$
2) $h(k,i,M) = (h_1(k,M) + i^2)\%M$
3) $h(k,i,M) = (h_1(k,M) + i + 3i^2)\%M$

Quadratic hashing generates secondary clustering: if 2 keys are hashed to the same first cell, they will collide in all subsequent cells

Sample problem:

Let $h_1(k,M) = k\%M$ and

$h(k,i,M) = (h_1(k,M) + 2i + i^2)\%M$

Give the first 4 cells that will be probed when inserting 19.

Same question for inserting 25 and 35.

Assume table size 10.

$M=10 \Rightarrow h_1(k,10) = k\%10$

$h(k,i,10) = (h_1(k,10) + 2i + i^2)\%10$

$$\boxed{h(k,i,10) = (k\%10 + 2i + i^2)\%10}$$

$k=19 \Rightarrow h(19,i,10) = (19\%10 + 2i + i^2)\%10 = (9 + 2i + i^2)\%10$

1st cell $(i=0) \Rightarrow h(19,0,10) = (9 + 2\cdot 0 + 0^2)\%10 = (9+0)\%10 = 9$

2nd cell $(i=1) \Rightarrow h(19,1,10) = (9 + 2\cdot 1 + 1^2)\%10 = (9+3)\%10 = 12\%10 = 2$

3rd cell $(i=2) \Rightarrow h(19,2,10) = (9 + 2\cdot 2 + 2^2)\%10 = (9+8)\%10 = 17\%10 = 7$

4th cell $(i=3) \Rightarrow h(19,3,10) = (9 + 2\cdot 3 + 3^2)\%10 = (9+15)\%10 = 24\%10 = 4$

$19 \rightarrow \boxed{9, 2, 7, 4}$

$k=25 \quad h(25,i,10) = (25\%10 + 2i + i^2)\%10 = (5 + 2i + i^2)\%10$

1st cell $(i=0) \Rightarrow h(25,0,10) = (5 + 2\cdot 0 + 0^2)\%10 = (5+0)\%10 = 5$

2nd cell $(i=1) \Rightarrow h(25,1,10) = (5 + 2\cdot 1 + 1^2)\%10 = (5+3)\%10 = 8\%10 = 8$

3rd cell $(i=2) \Rightarrow h(25,2,10) = (5 + 2\cdot 2 + 2^2)\%10 = (5+8)\%10 = 13\%10 = 3$

4th cell $(i=3) \Rightarrow h(25,3,10) = (5 + 2\cdot 3 + 3^2)\%10 = (5+15)\%10 = 20\%10 = 0$

$25 \rightarrow \boxed{5, 8, 3, 0}$ → secondary clustering

$k=35 \quad h(35,i,10) = (35\%10 + 2i + i^2)\%10 = (5 + 2i + i^2)\%10$

$35 \rightarrow \boxed{5, 8, 3, 0}$

Double Hashing

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Use one hash function to find the first cell, and another hash function to compute a "jump size" used to compute indexes of cells probed next.

E.g. $h_1(k,M) = k\%M$, $h_b(k) = 1+(k\%9)$

double hashing function: $h(k,i,M) = [h_1(k,M) + i \cdot h_b(k)]\%M$

Assume table size 10. Give the indexes of the the first 4 cells probed when inserting 25 using the above double hasing function

$M=10 \Rightarrow h(k,i,10) = [k\%10 + i \cdot h_b(k)]\%10$

$k=25 \Rightarrow h_b(k) = h_b(25) = 1+(25\%9) = 1+7 = 8$

$h_1(k,10) = h_1(25,10) = 25\%10 = 5$

$h(25,i,10) = (5 + i \cdot 8)\%10$

1st cell $(i=0) \Rightarrow h(25,0,10) = (5+0\cdot 8)\%10 = (5+0)\%10 = 5$

2nd cell $(i=1) \Rightarrow h(25,1,10) = (5+1\cdot 8)\%10 = (5+8)\%10 = 13\%10 = 3$

3rd cell $(i=2) \Rightarrow h(25,2,10) = (5+2\cdot 8)\%10 = (5+16)\%10 = 21\%10 = 1$

4th cell $(i=3) \Rightarrow h(25,3,10) = (5+3\cdot 8)\%10 = (5+24)\%10 = 29\%10 = 9$

25 → 5, 3, 1, 9

$k=19 \Rightarrow h_1(19,10) = 19\%10 = 9$, $h_b(19) = 1+(19\%9) = 1+1 = 2 \Rightarrow$

$h(19,i,10) = (9 + i\cdot 2)\%10$

1st cell $(i=0) \Rightarrow h(19,0,10) = (9+0\cdot 2)\%10 = (9+0)\%10 = 9$

2nd cell $(i=1) = h(19,1,10) = (9+1\cdot 2)\%10 = (9+2)\%10 = 11\%10 = 1$

3rd cell $(i=2) \Rightarrow h(19,2,10) = (9+2\cdot 2)\%10 = (9+4)\%10 = 13\%10 = 3$

4th cell $(i=3) \Rightarrow$ - - -

$k=35 \Rightarrow h_1(35,10) = 35\%10 = 5$ $h_b(35) = 1+(35\%9) = 1+8 = 9$

1st cell $(i=0)$ $h(35,0,10) = (5 + i\cdot 9)\%10 = (5+0\cdot 9)\%10 = 5$

2nd cell $(i=1)$ $h(35,1,10) = (5+1\cdot 9)\%10 = (5+9)\%10 = 14\%10 = 4$