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Part A: Hash Table Definitions (Conceptual Understanding)

Q1. Define "collision" in the context of hash tables.

A1:

different keys with same hash values
hash $\leftarrow h(a) = b$
 $h(c) = b$ \rightarrow 重複

Q2. What is a "bucket" in a hash table?

A2:

index
索引的格子, 分類的依據
a b
c d

Q3. Define "load factor (α)" and explain why it affects performance.

A3:

$\alpha = \frac{n}{m} \rightarrow$ loading 的數量
 $m \rightarrow$ the size

在 separate 時 α 小, 時 $O(1)$ 造成影響
在 search 時 with chaining
best $O(1)$, average $O(1 + \alpha)$, worst $O(n)$

Q4. What is "primary clustering," and which probing method suffers from it?

A4:

linear probing

↓ 數值都落在同一範圍

$57 \bmod 10 = 7$ $17 \bmod 10 = 7$ 移到 [8]
 $67 \bmod 10 = 7$ 移到 [9]

Q5. What is "secondary clustering," and how is it different from primary clustering?

A5:

quadratic probing
二次過平方後會像個環的數值, 一直碰到相同
例 $(3 + \text{index}^2) \bmod m$
 $0 \quad 3 + 0 + 0 = 3$
 $1 \quad 3 + 1 + 1 = 5$
 $2 \quad 3 + 4 + 4 = 11 \quad 11 \bmod 10 = 1$
 $3 \quad 3 + 9 + 9 = 21 \quad 21 \bmod 10 = 1$
 $4 \quad 3 + 16 + 16 = 35 \quad 35 \bmod 10 = 5$

Q6. Briefly explain the difference between:

- Open addressing
- Separate chaining

A6:

Open addressing 是以像 linear probing / quadratic probing / double hash 等方式處理 collision
Separate chaining 則以遇到碰撞的都以 linked list 接起來

Part B: Hash Function Calculation (Collision & Pattern Observation)

Show your steps clearly.

Hash Function 1 — Division Method

$$h_1(k) = k \bmod 10$$

Hash Function 2 — Folding Method

Split key into two-digit chunks and sum the chunks.

$$h_2(k) = (\text{sum of 2-digit groups}) \bmod 11$$

Example:

Key = 8429 \rightarrow groups: 84 + 29 \rightarrow 113 \rightarrow 113 mod 11 = 3

Q7. (Compute using Hash Function 1)

Given keys: 27, 37, 47, 57, 67

Compute their hash values using:

$$h_1(k) = k \bmod 10$$

A7:

$$h(27) = 27 \bmod 10 = 7$$

$$h(57) = 7$$

$$h(37) = 7$$

$$h(67) = 7$$

$$h(47) = 7$$

Q8. (Identify collision pattern)

From your results in Q7:

- What pattern do you observe? the same hash values
- Explain why these keys collide.

個位數都是 7, 所以 hash value 都一樣, 就造成

A8:

碰撞

Q9. (Compute using Hash Function 2)

Compute $h_2(k)$ for: 1234, 9217, 4519, 9902

A9: $h_2(1234) \rightarrow 12 + 34 \rightarrow 46 \rightarrow 46 \bmod 11 = 2$

$$h_2(9217) \rightarrow 92 + 17 \rightarrow 109 \rightarrow 109 \bmod 11 = 10$$

$$h_2(4519) \rightarrow 45 + 19 \rightarrow 64 \rightarrow 64 \bmod 11 = 9$$

$$h_2(9902) \rightarrow 99 + 02 \rightarrow 101 \rightarrow 101 \bmod 11 = 2$$

Q10. (Compare distribution)

- Which hash function (h_1 or h_2) produced more collisions for the input set?
- Which seems to spread keys more evenly?
- Provide 1–2 sentences of explanation.

A10: h_1 produced more collisions. h_2 seems to spread keys more evenly.

\downarrow \because 5 個值都是 7, 全部造成碰撞 (h_1), 而 h_2 成功讓 hash value 散佈在 2, 9, 10

雖然也有碰撞。加上 mod 11 是質數又較 10 來得好。

11 > 10, 又不會有因數導致 hash value 一樣