basic HASHING

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- INSERT
- DELETE

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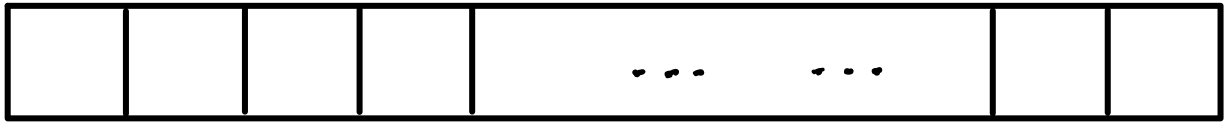
not "expected worst-case",
it's just average time.

For some hashing methods, some operations can be $O(1)$ worst-case.

The simplest form of hashing → Direct access table

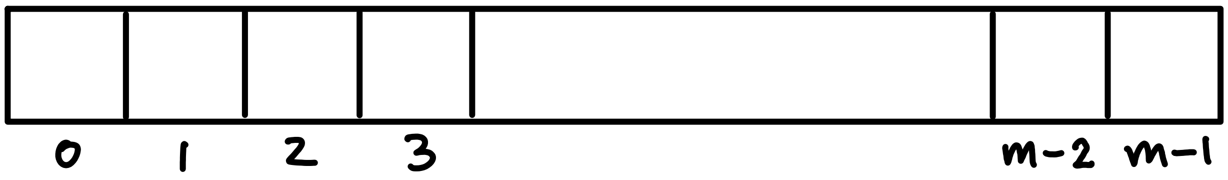


The simplest form of hashing → Direct access table

Assume keys are distinct

and come from a small $\underbrace{\text{set of possible values}}_{\text{Universe}}$, $\mathcal{U}$

e.g., $\mathcal{U} = \{0, 1, 2, \ldots, m-1\}$



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Universe

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$m = 74$

T

0	1	2	3		72	73
0	1	2	3		m−2	m−1

insert$(T, k) \rightarrow T[k] = k$

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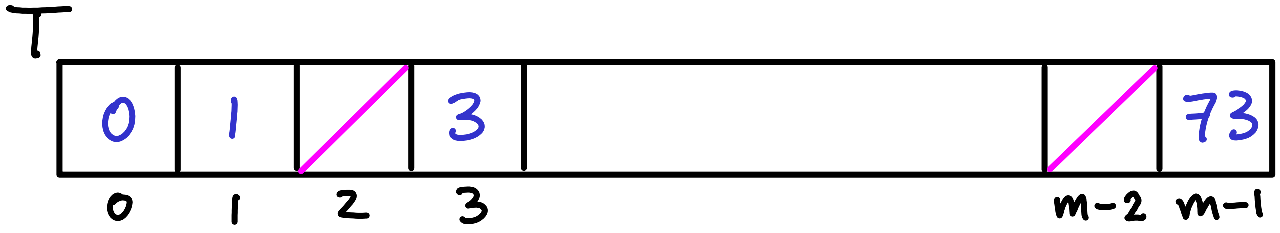

insert$(T, k) \rightarrow T[k] = k$ // delete$(T, k) \rightarrow T[k] = \varnothing$

The simplest form of hashing → Direct access table

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$m = 74$

T

0	1		3			73
0	1	2	3		m−2	m−1

search(T, 3) = 3 // insert(T, k) → T[k] = k // delete(T, k) → T[k] = $\emptyset$

Often U is larger than the available space, m

but we only need to deal with a subset S of U, where $|S| \leq m$

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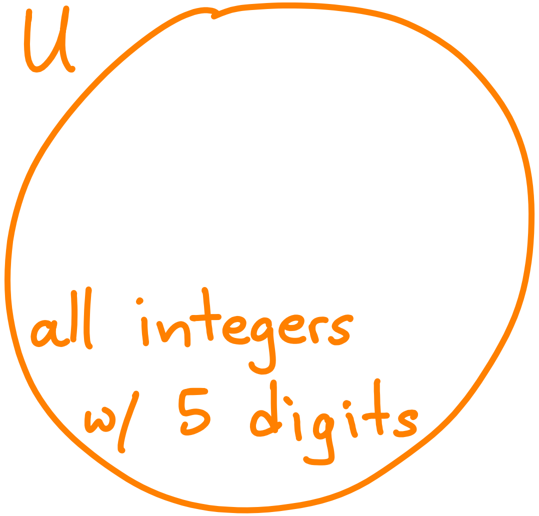

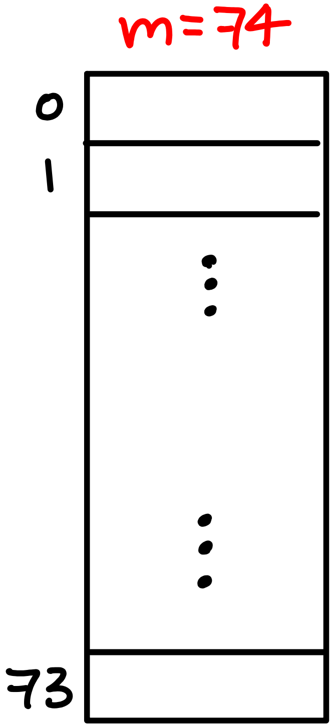

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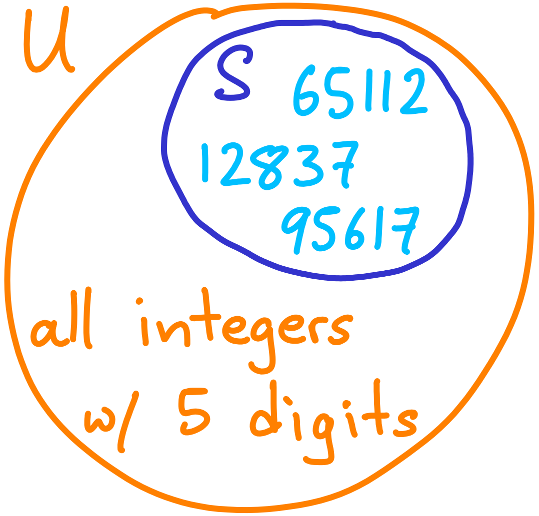

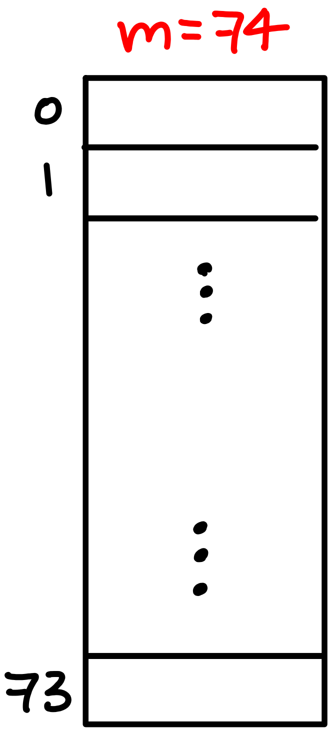

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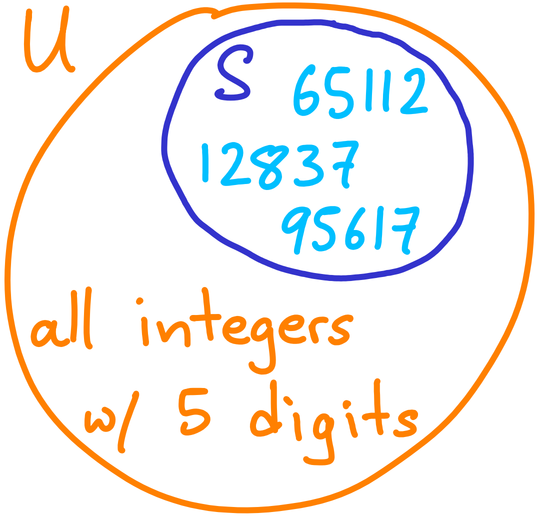

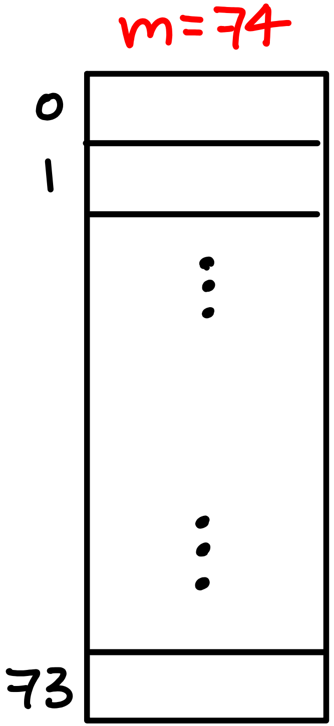

h: hash function

maps keys to T

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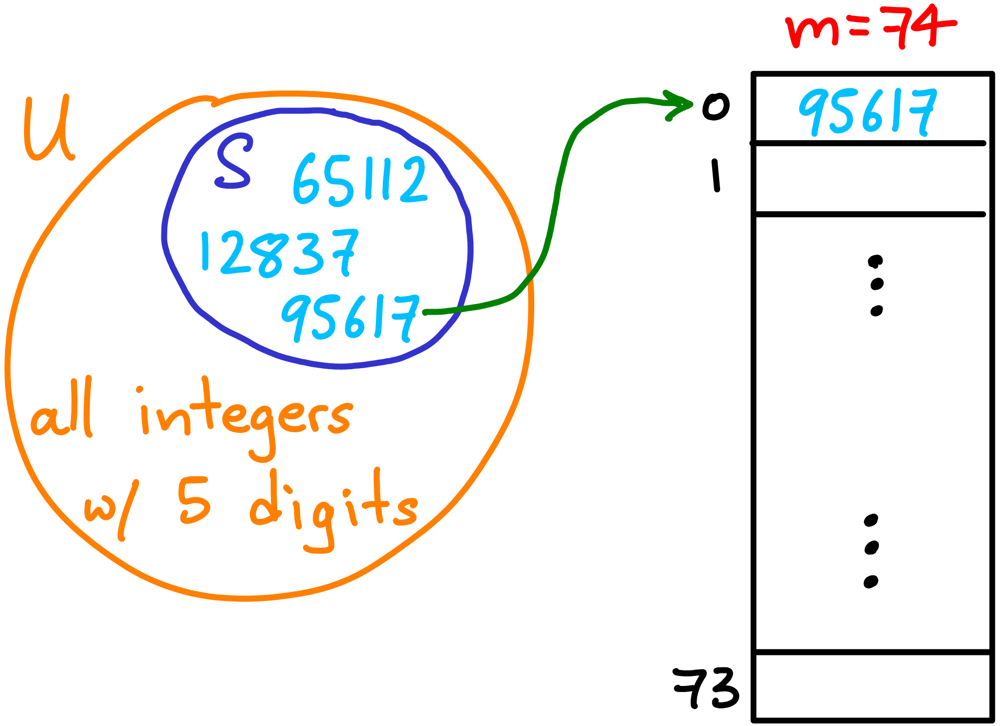

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$h(95617) = 0$

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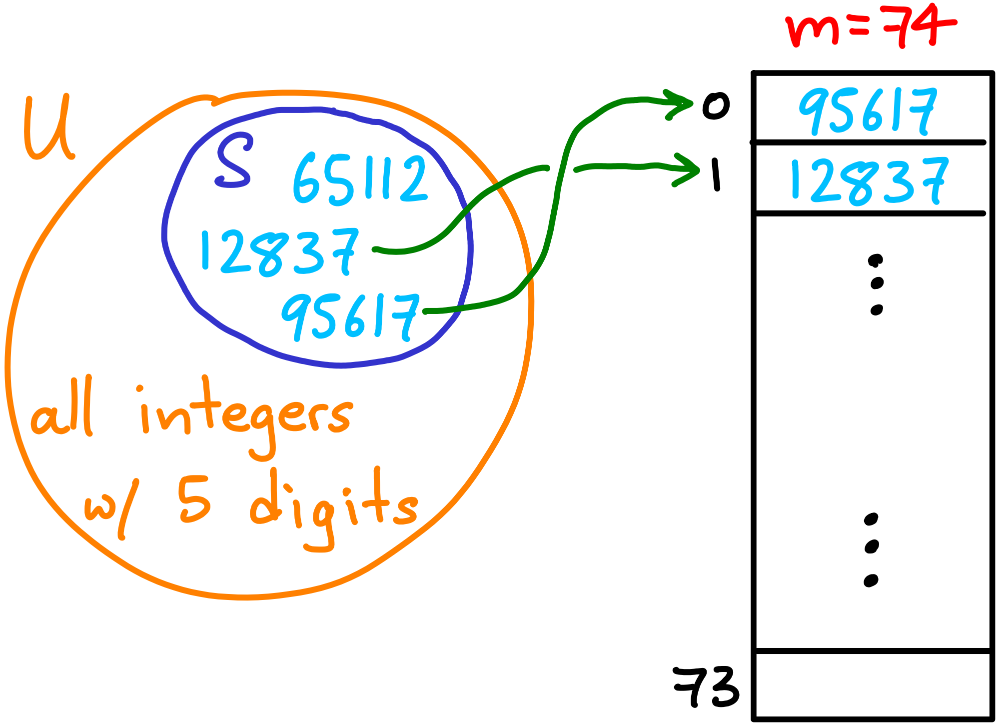

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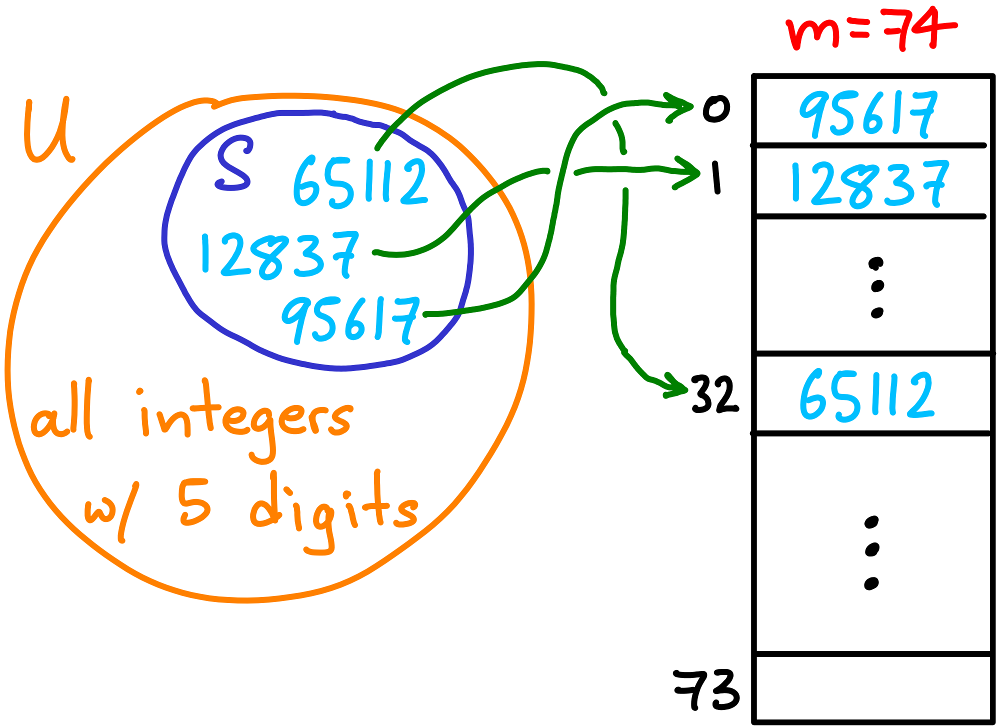

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Example: look up this semester's ALGO students using only their first name & academic level

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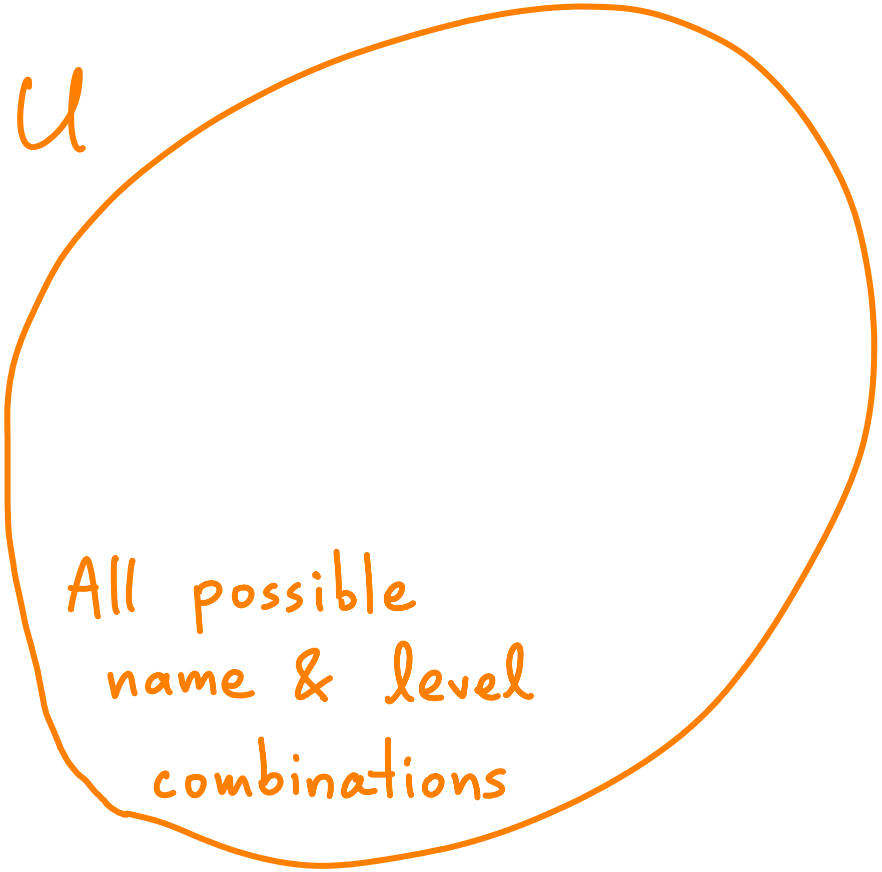

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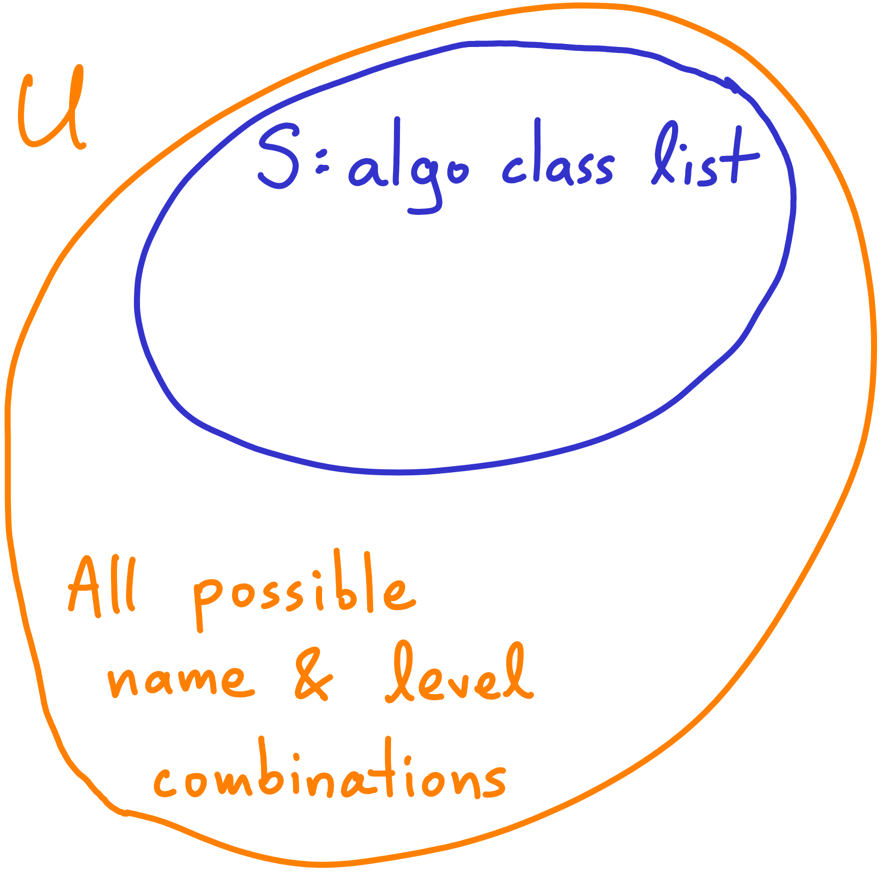
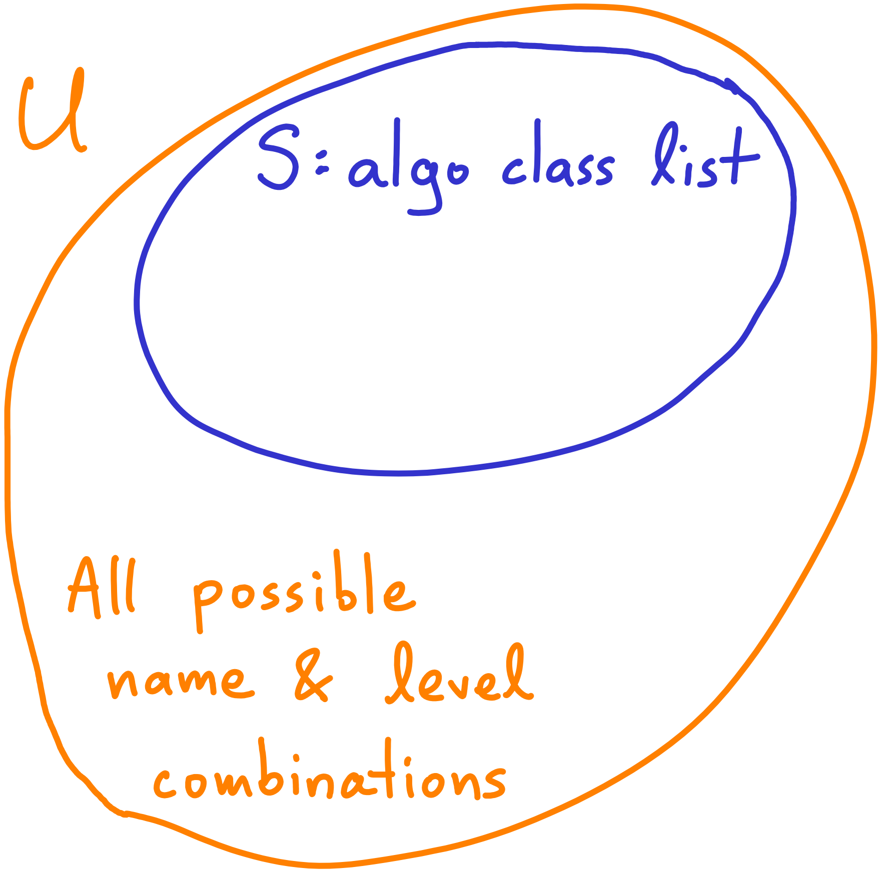


- take 1st letter of name, map to number → $N = \{1 \ldots 26\}$



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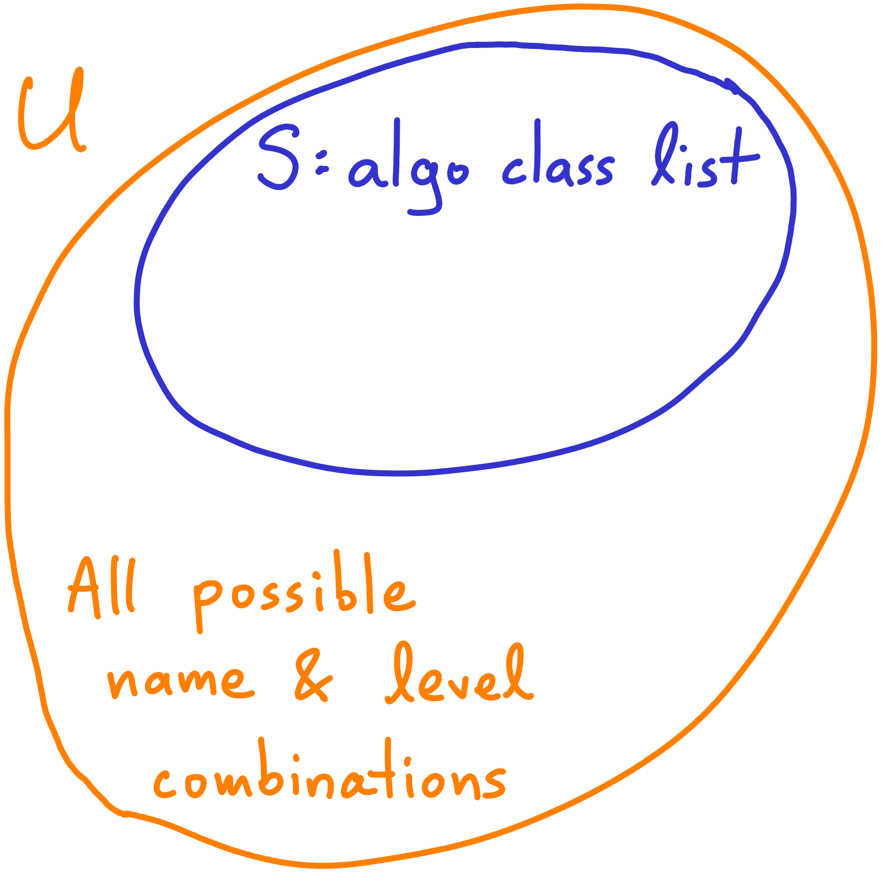

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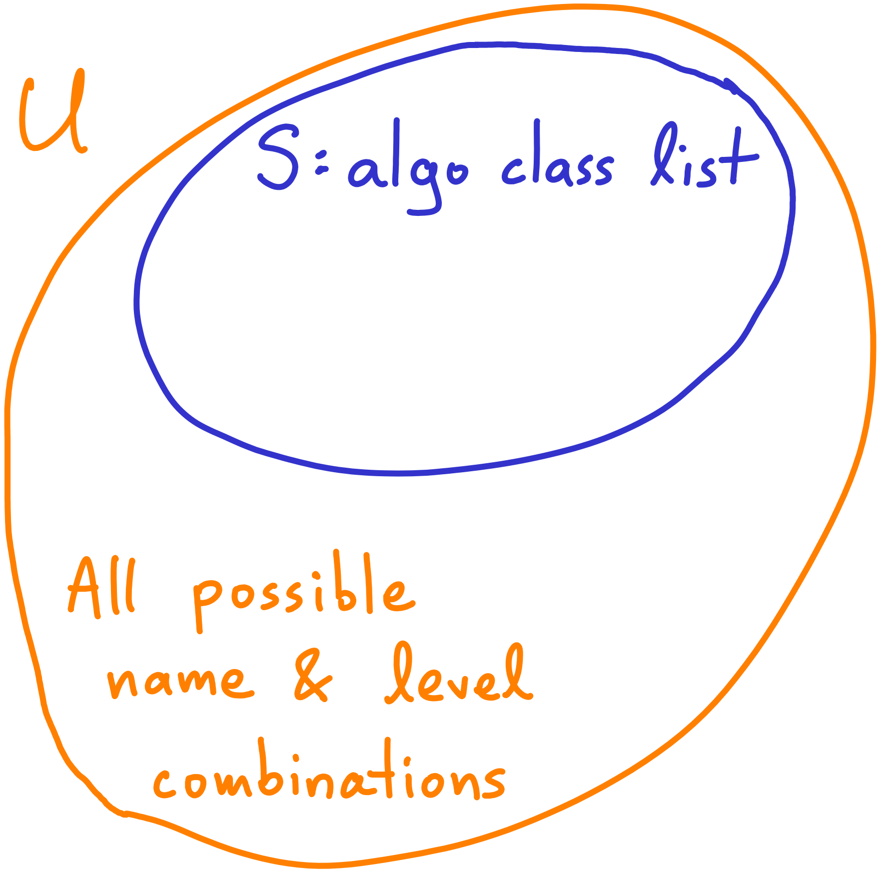
$$h(\text{student}) = h(L,N) = 10 \cdot N + L$$

unique per pair N,L



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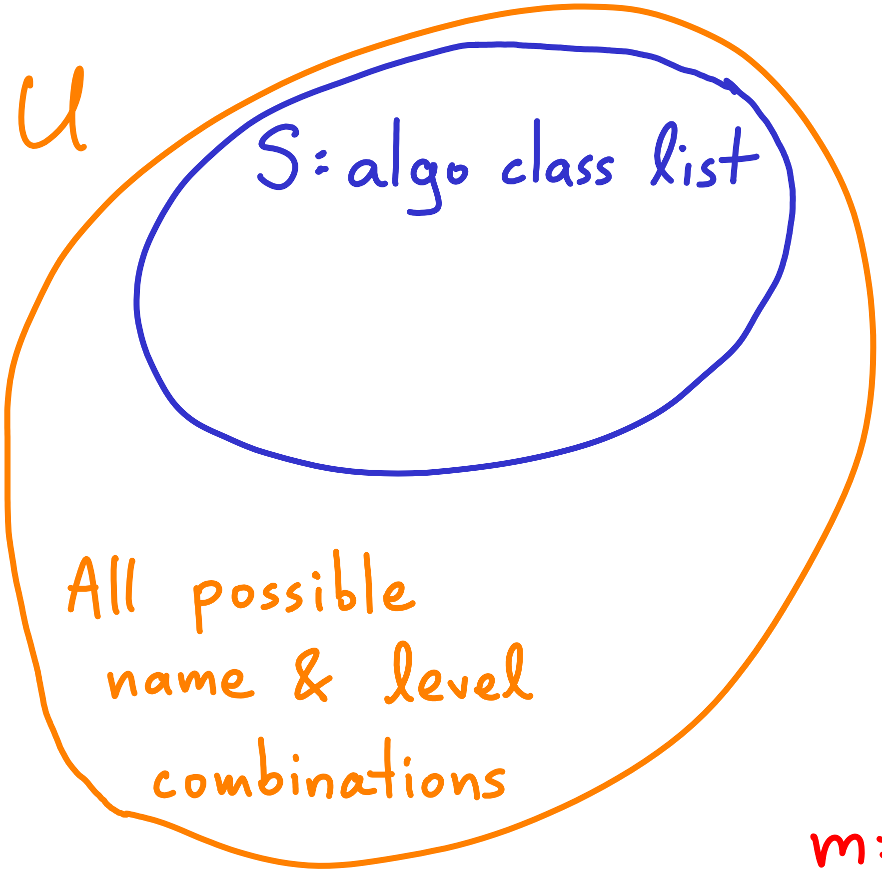
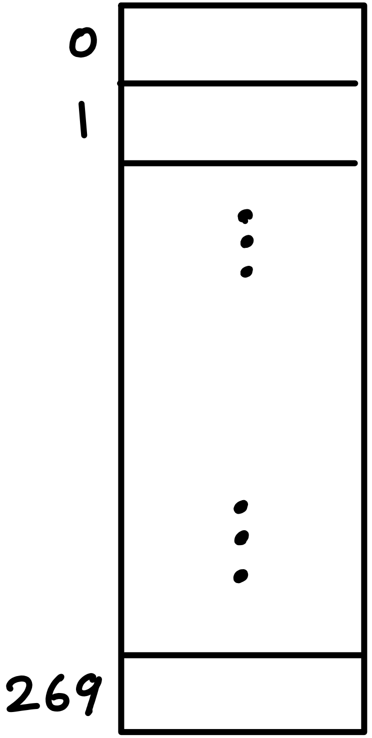


m = 270



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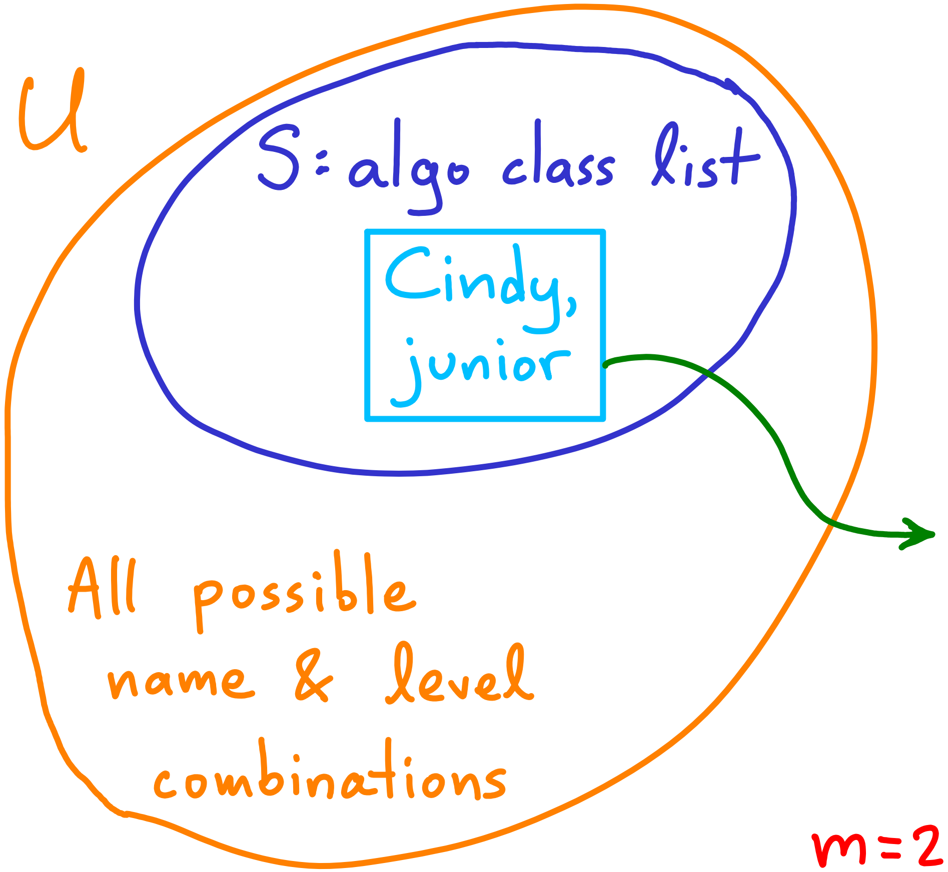

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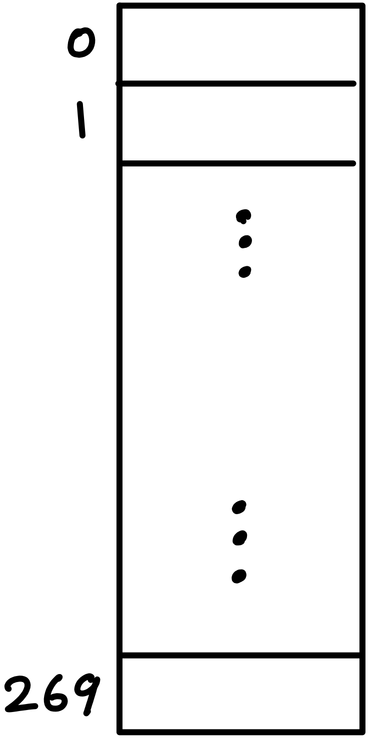

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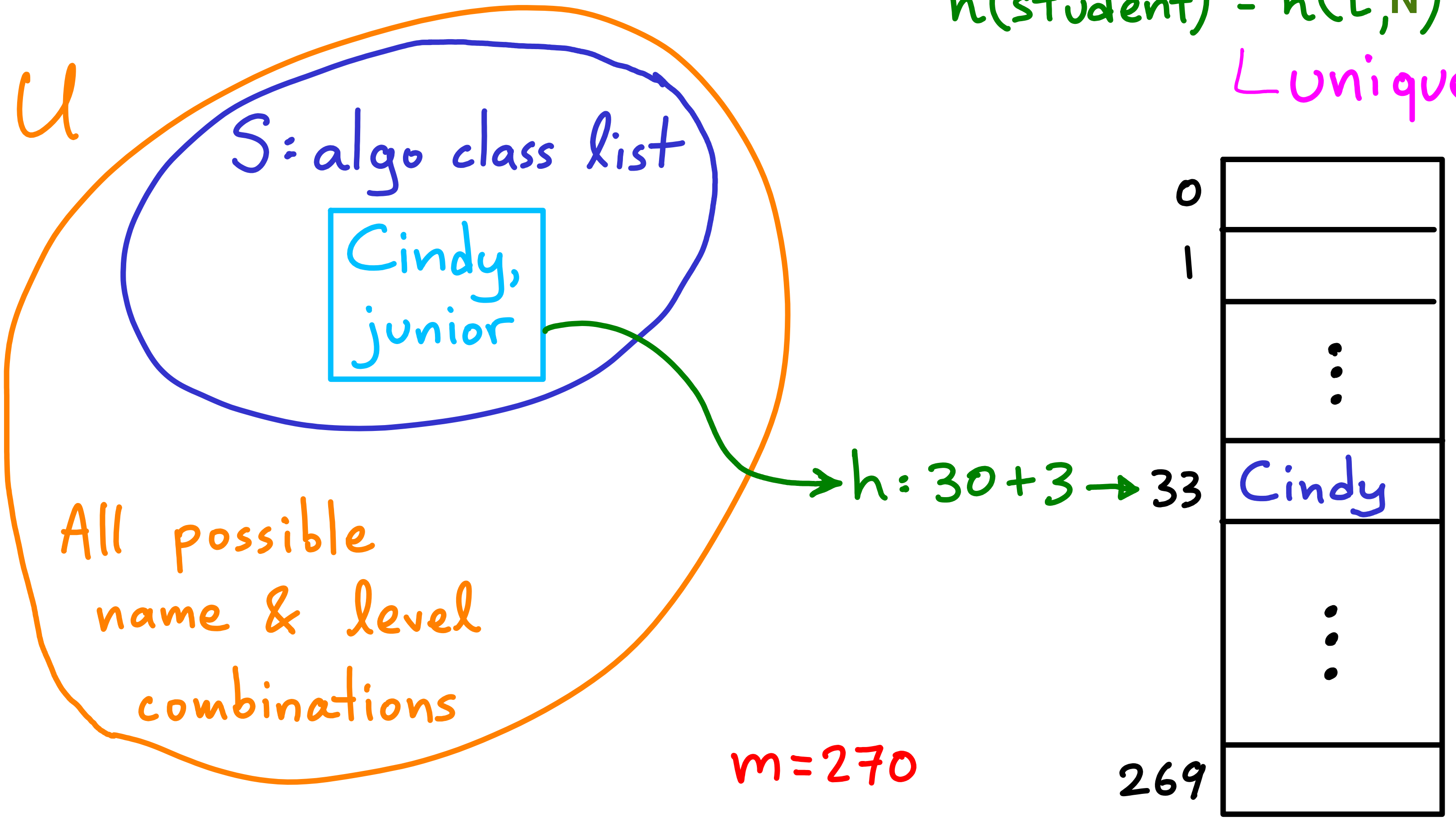

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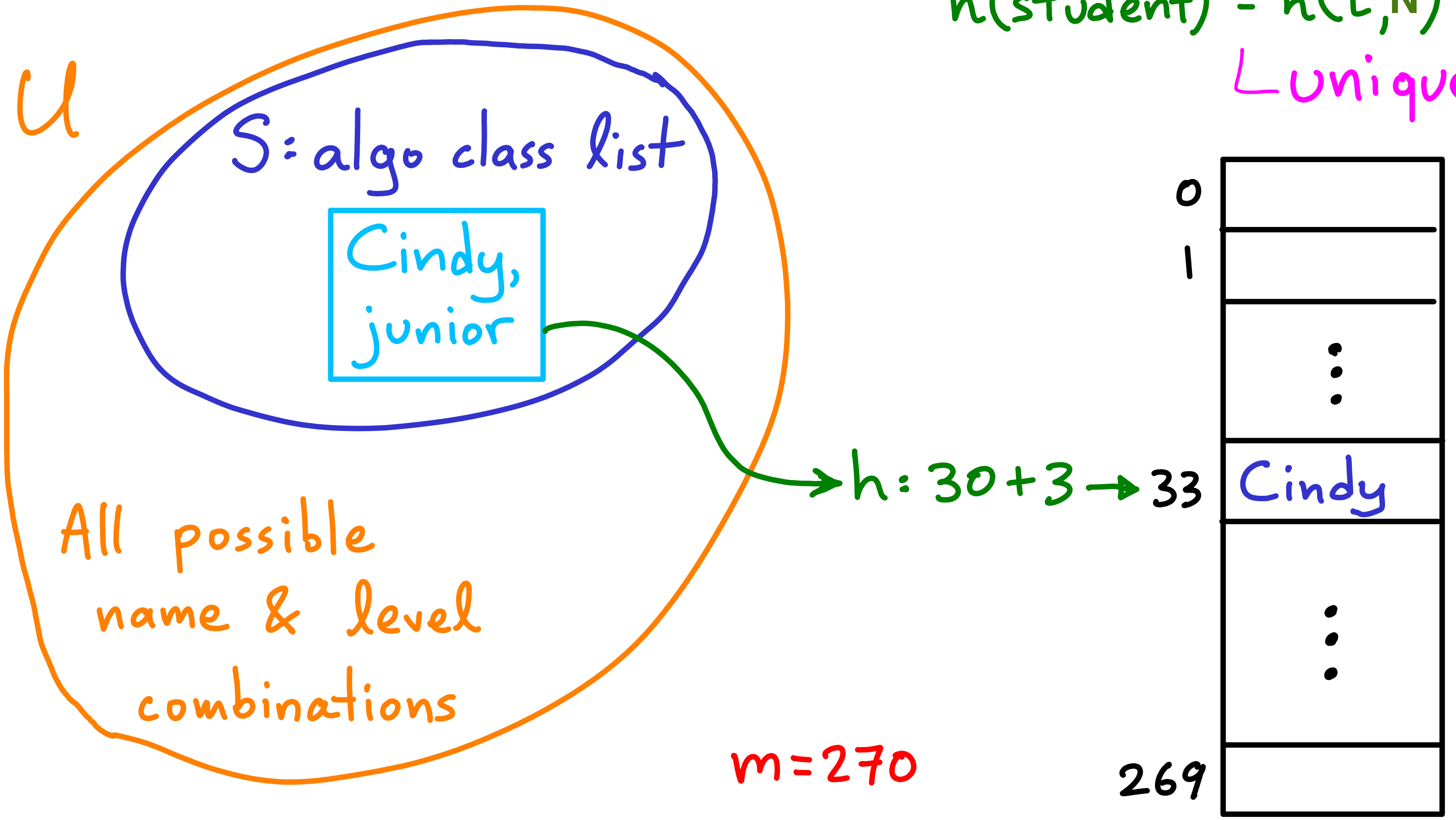

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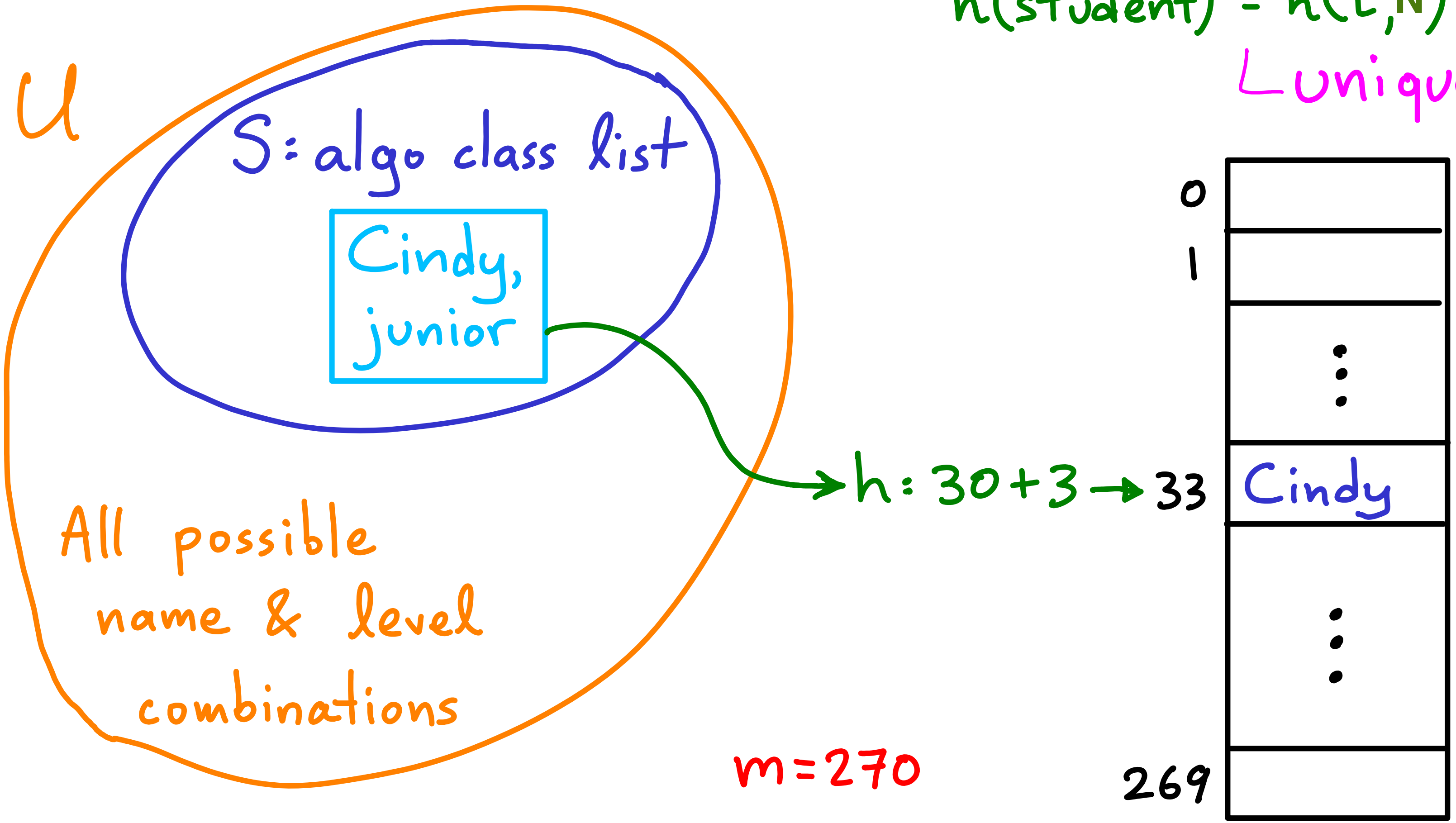

PROBLEMS?

(1) some permanently empty slots

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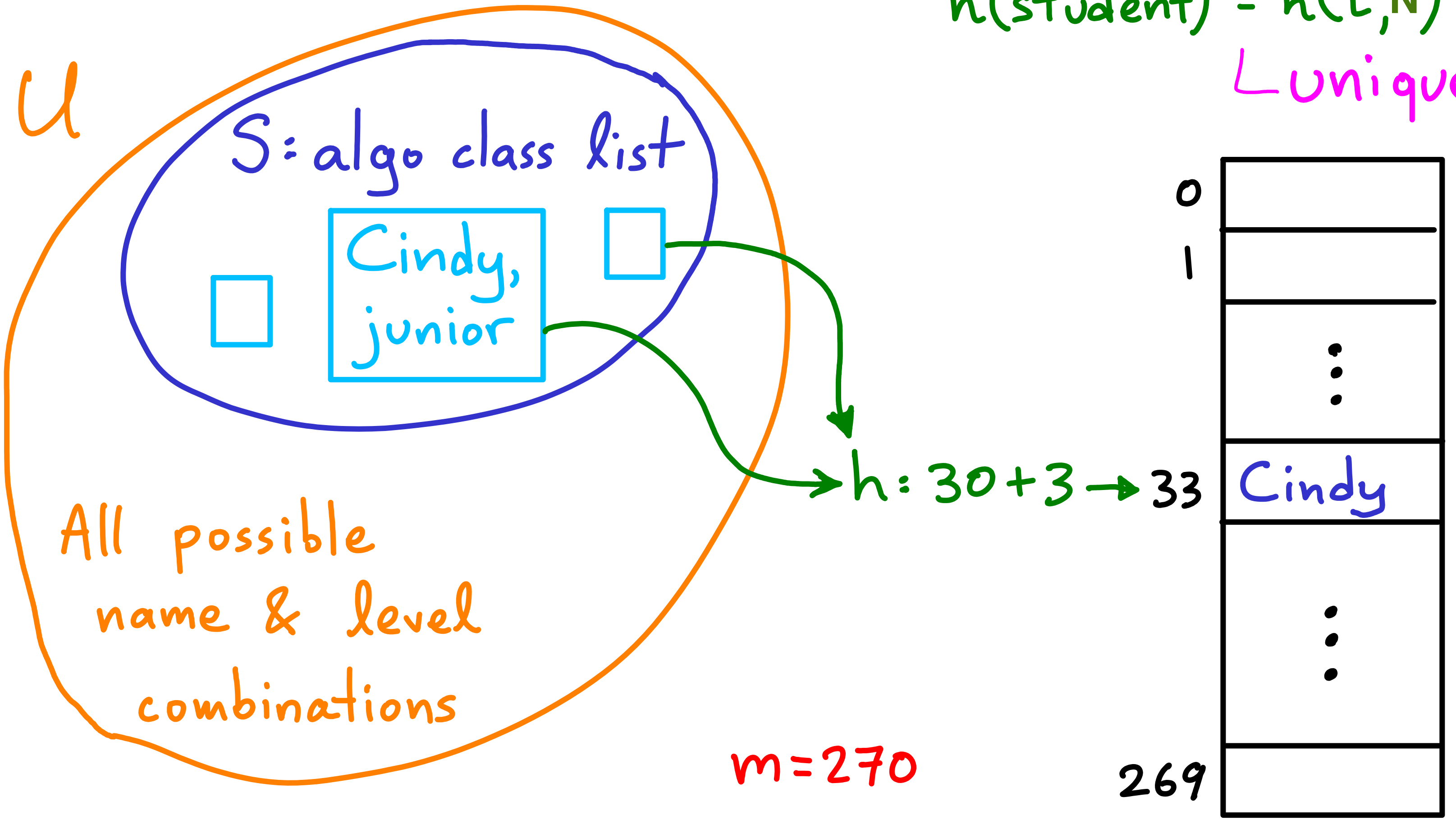

PROBLEMS?

(1) some permanently empty slots

(2) collisions

Could use more of the given info to design a more complicated $h(\ )$

↪ might reduce collisions

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We want to use a simple h( ) and deal with collisions