MAKE
SCHOOL

HASH TABLES

Not just for breakfast anymore

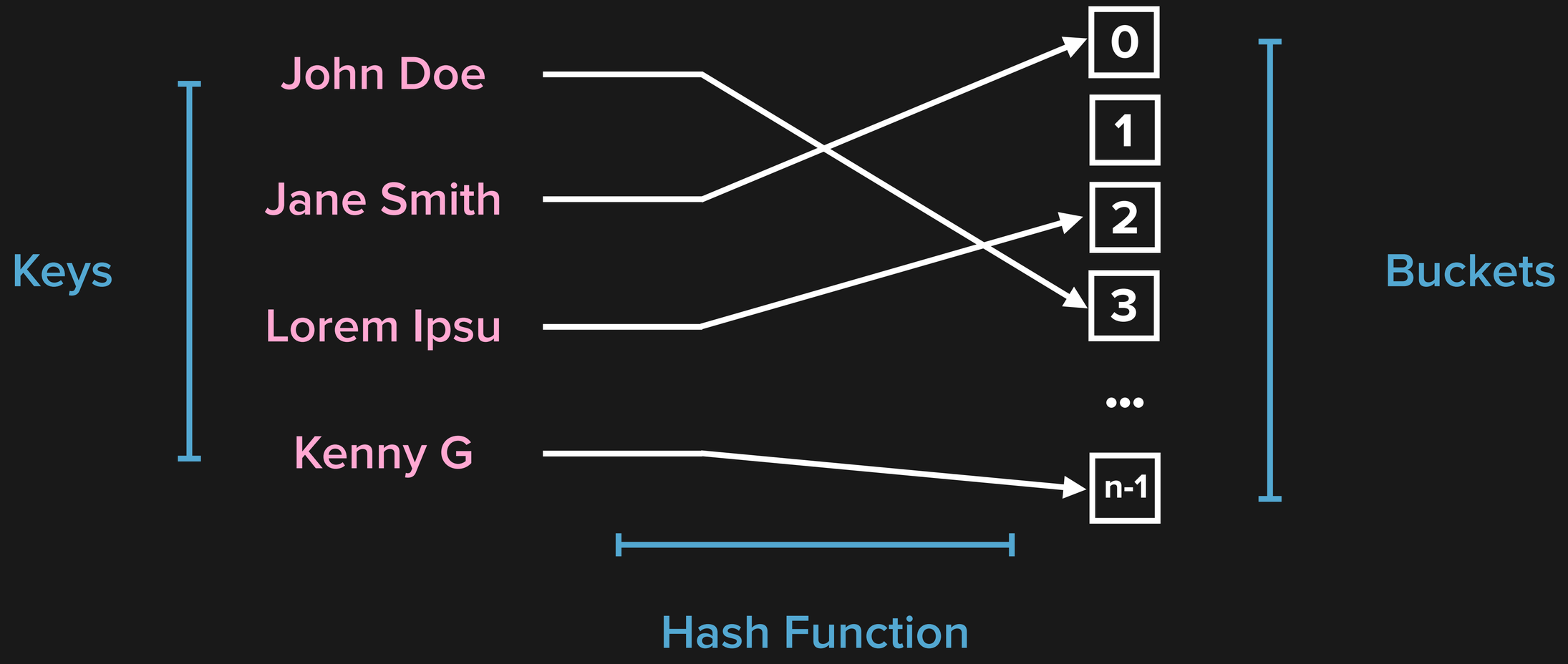
HASH TABLES

Maps keys ➜ objects

`dict()` creates a hash table

Used because of strong average case performance

HASH TABLES



HASH FUNCTIONS

Converts a variable-size input to a fixed-size output

Same input ➜ same output

Input can be anything - string, pointer, custom class

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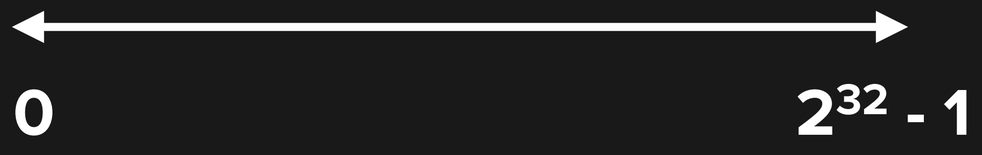
IDEAL HASH*

Repeatable

Fast

Output is unsigned integer

Randomly distributes keys among output space



Small differences in input result in large differences in output

*Different for cryptographic hash functions

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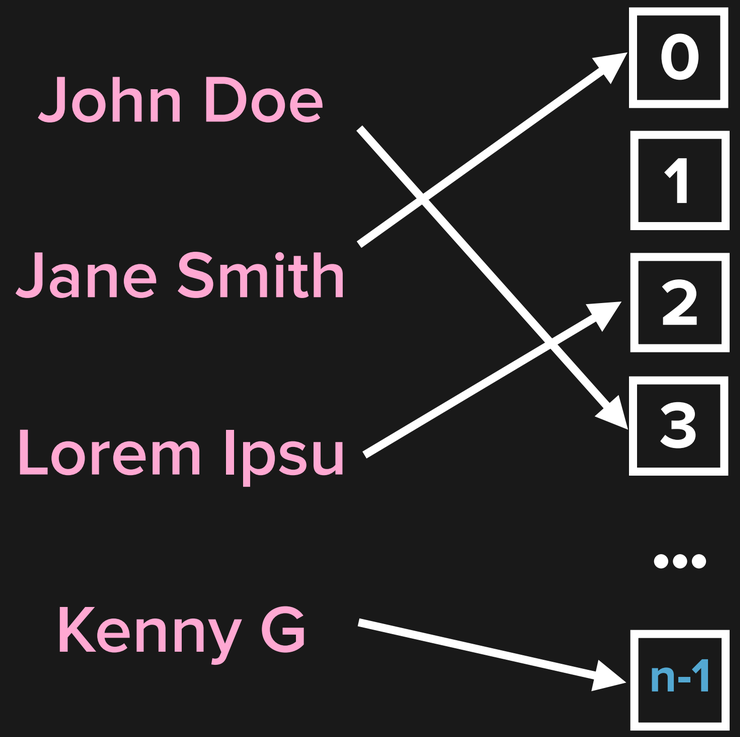
WHICH BUCKET?

```
bucket = hash(key) % n
```



COLLISIONS

It is *impossible* to map all possible input to a fixed output space without some inputs generating the same output

Differing input generating the same output is a collision

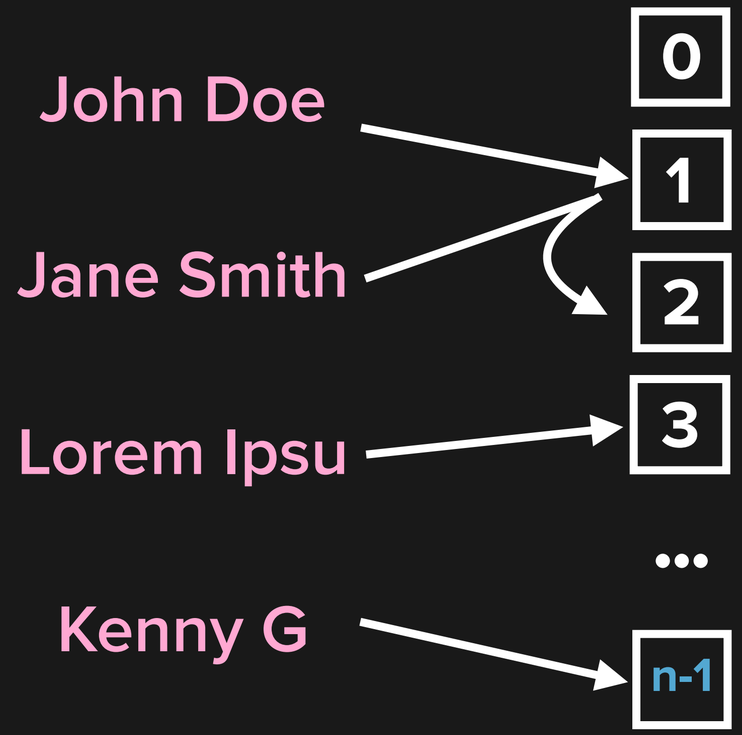
LINEAR PROBING

Each bucket contains one object

On collision - go to next open bucket, add object there

To retrieve - find bucket, if that's not object, iterate buckets until you find it

`dict` does it in a similar way

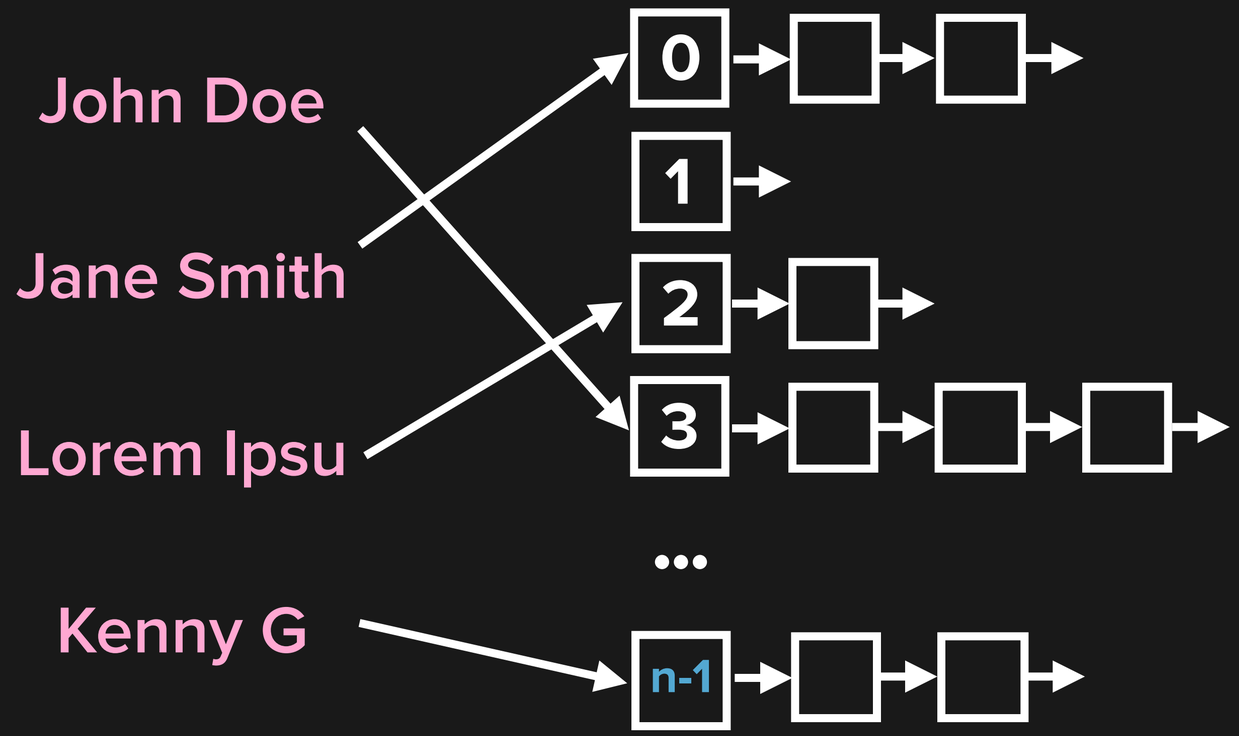


CHAINING

Each bucket contains a linked list

On collision - add to end of the linked list

To retrieve - find bucket, find in linked list



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LOAD FACTOR

```
Load Factor = entries / buckets
```

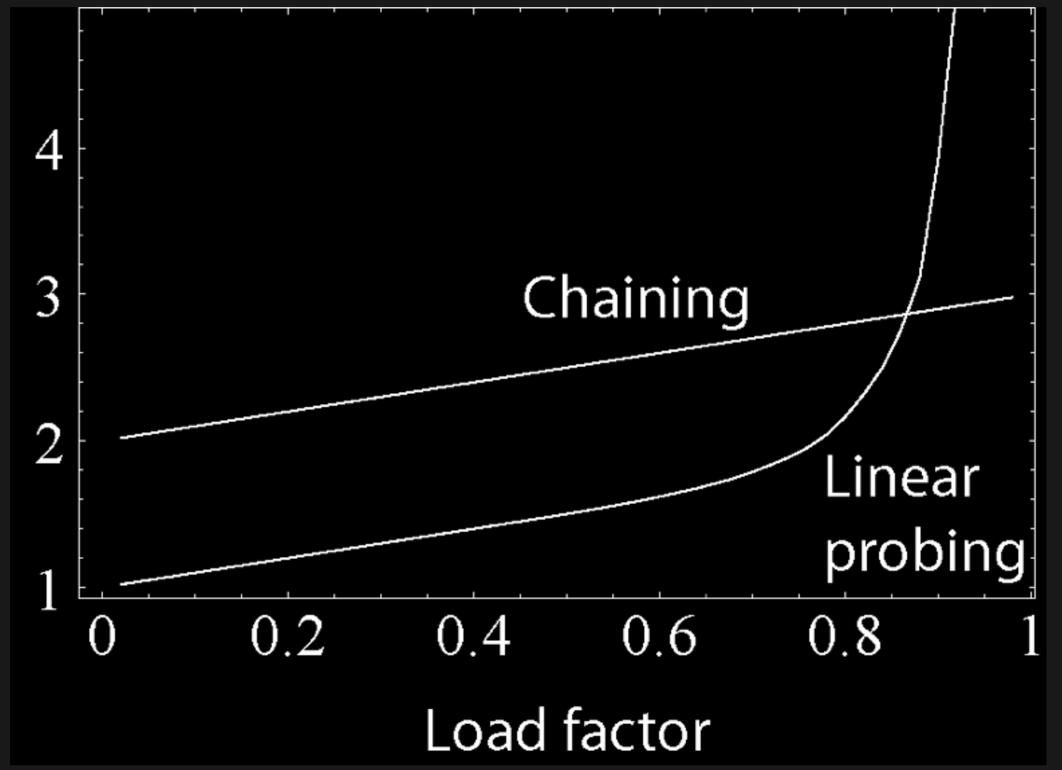
For **76** entries in a **128** bucket hash table,

that's **76 / 128 = 0.59375**

LOAD FACTOR

Load factor affects performance

Collision resolution affects performance



RESIZE HASH TABLE

Once the load factor reaches a certain threshold (usually $^{2}/_{3}$ for linear probing) the table is resized larger

Generate new buckets, iterate through each of the entries and rehash, re-add them to the new buckets

HASH TABLE COMPLEXITY ANALYSIS

	Average Case	Worst Case
Space	O(n)	O(n)
Search	O(1)	O(n)
Insert	O(1)	O(n)
Delete	O(1)	O(n)

STRING HASHING

Strings are lists of chars

Chars have numerical values

Add up the chars - there's your hash!
(Lose Lose algorithm)

But `hash("dog") == hash("god")`

https://wiki.python.org/moin/TimeComplexity

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