MAKE SCHOOL

HASH TABLES

Not just for breakfast anymore

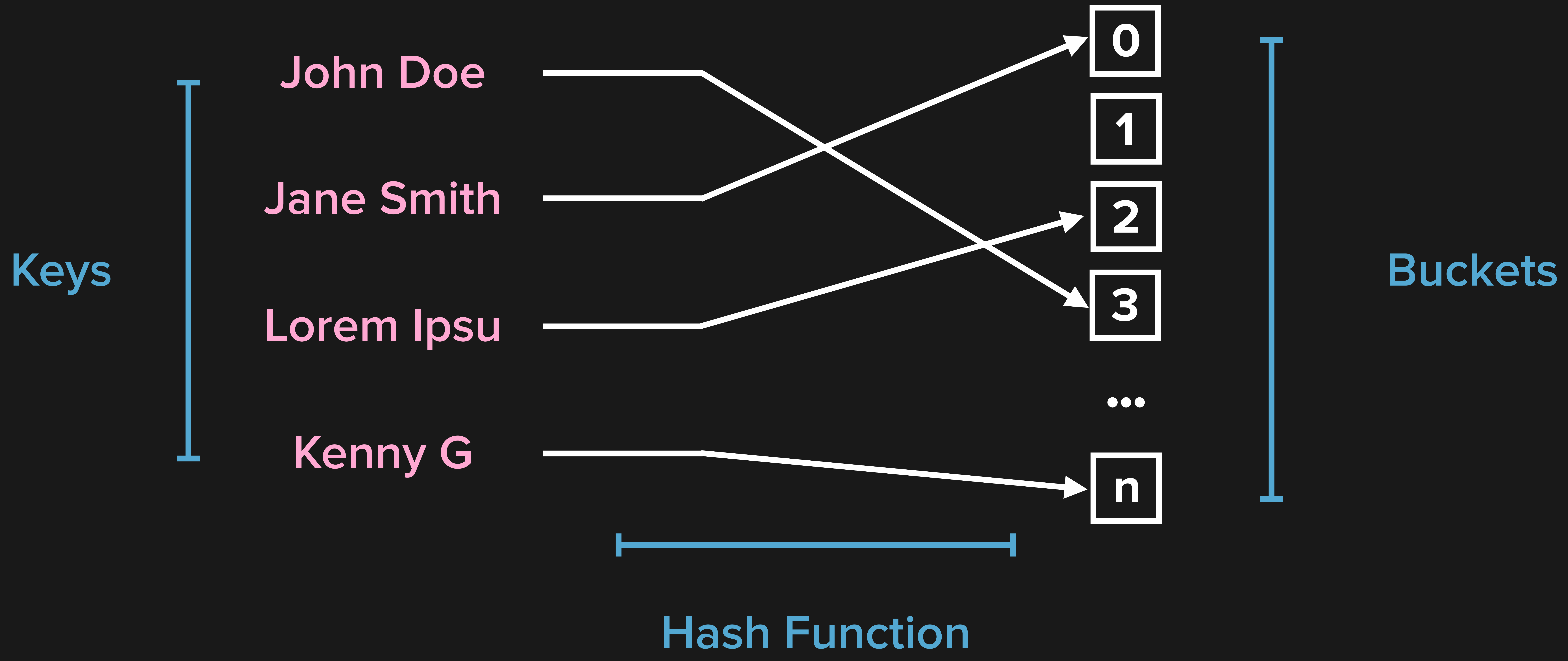
HASH TABLES

Maps keys ➔ objects

`dict()` creates a hash table

Used because of strong average case performance

HASH TABLES


Keys
John Doe
Jane Smith
Lorem Ipsu
Kenny G
0
1
2
3
...
n
Buckets
Hash Function

HASH FUNCTIONS

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

Same input ➔ same output

Input can be anything - string, pointer, custom class

John Doe	$\longrightarrow$	512340
Jane Smith	$\longrightarrow$	408749
Lorem Ipsu	$\longrightarrow$	943275
John Doe	$\longrightarrow$	512340

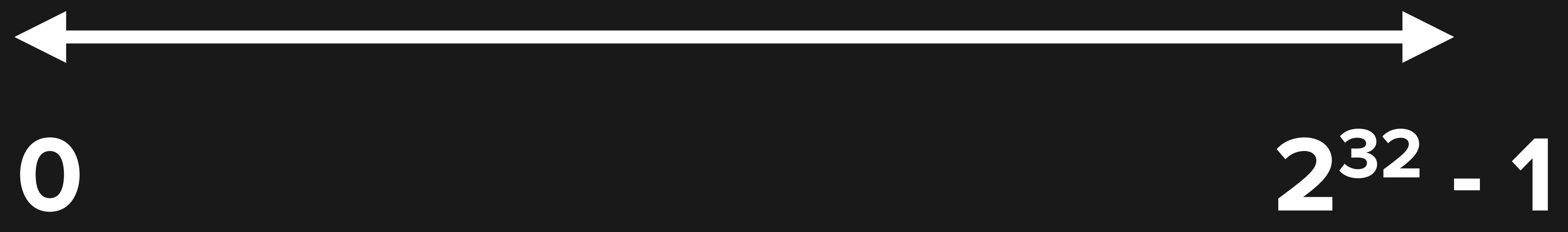
IDEAL HASH*

Repeatable

Fast

Output is unsigned integer

Randomly distributes keys among output space

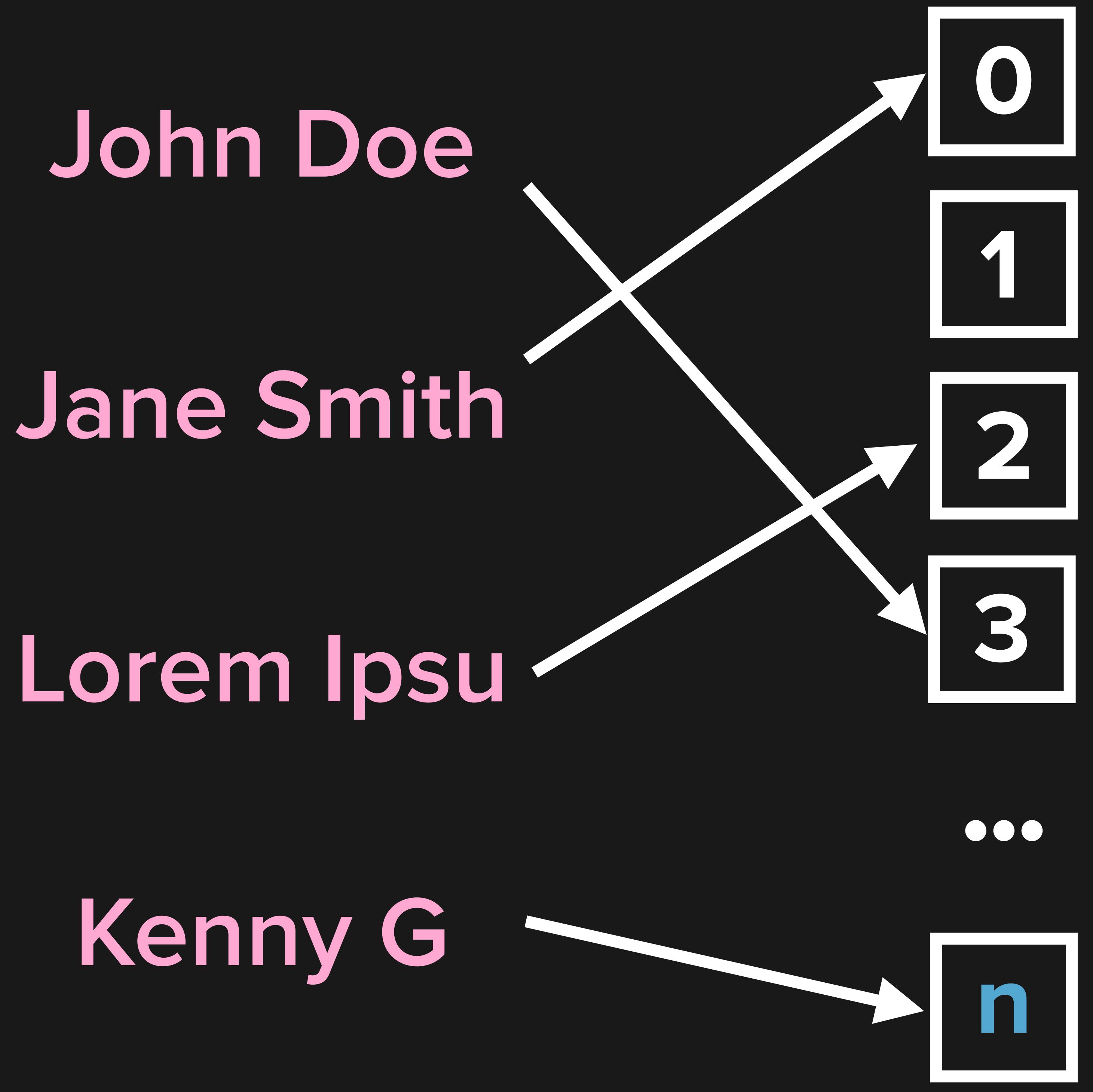


Small differences in input result in large differences in output

**Different for cryptographic hash functions*

WHICH BUCKET?

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



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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

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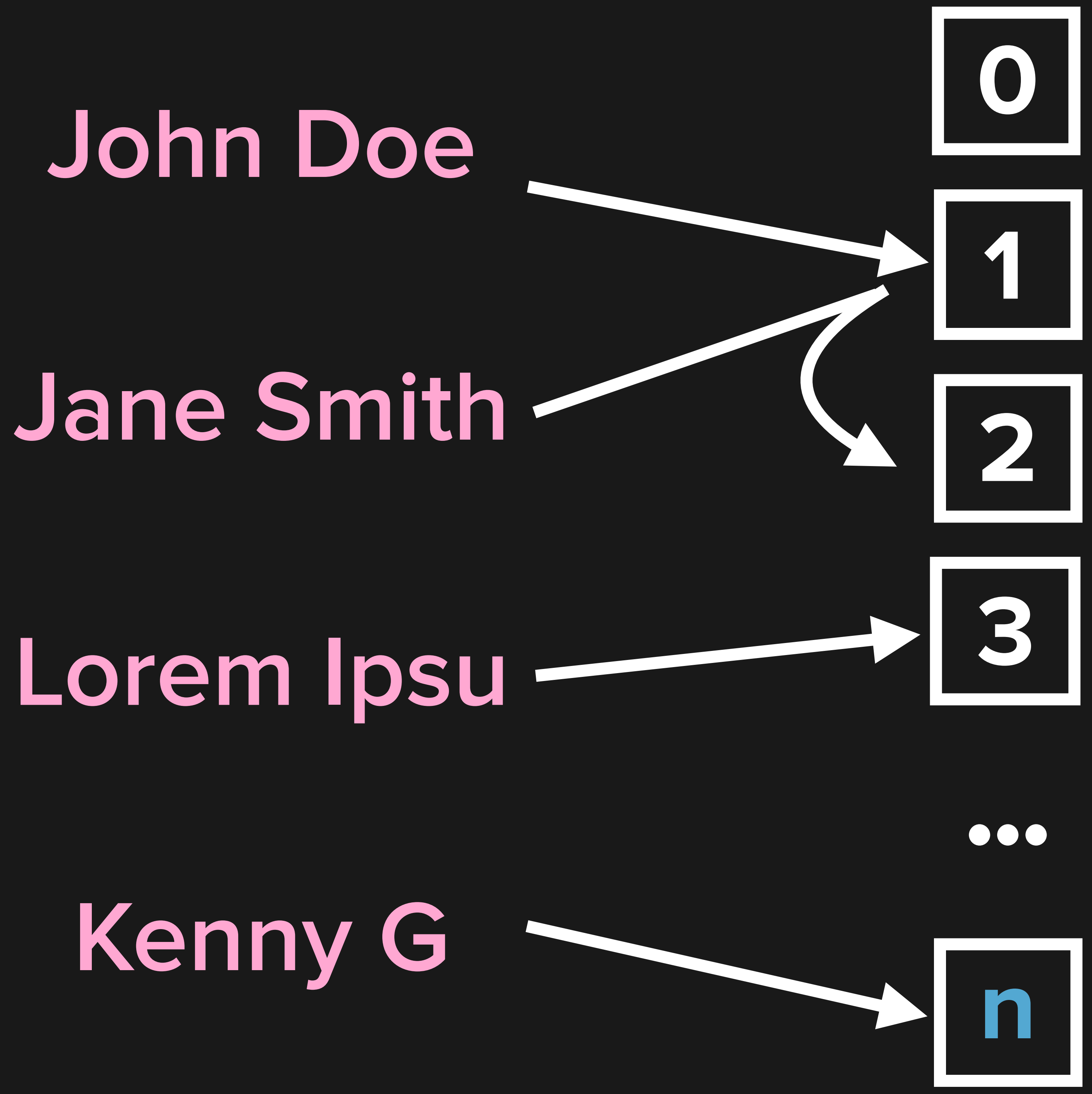
LINEAR PROBING

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

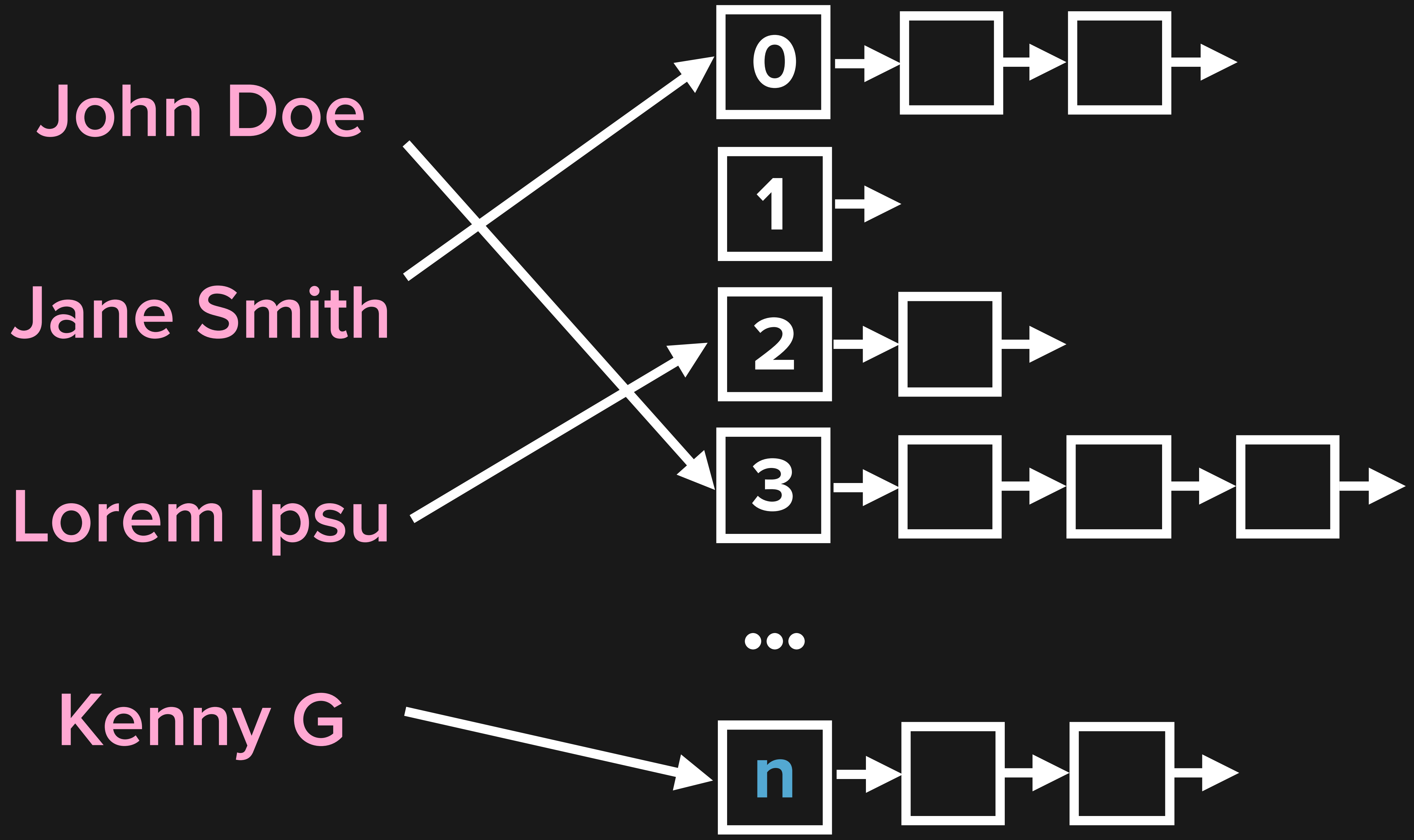


CHAINING

Each bucket contains a linked list

On collision - add to end of the linked list

To retrieve - find bucket, find in linked list



LOAD FACTOR

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

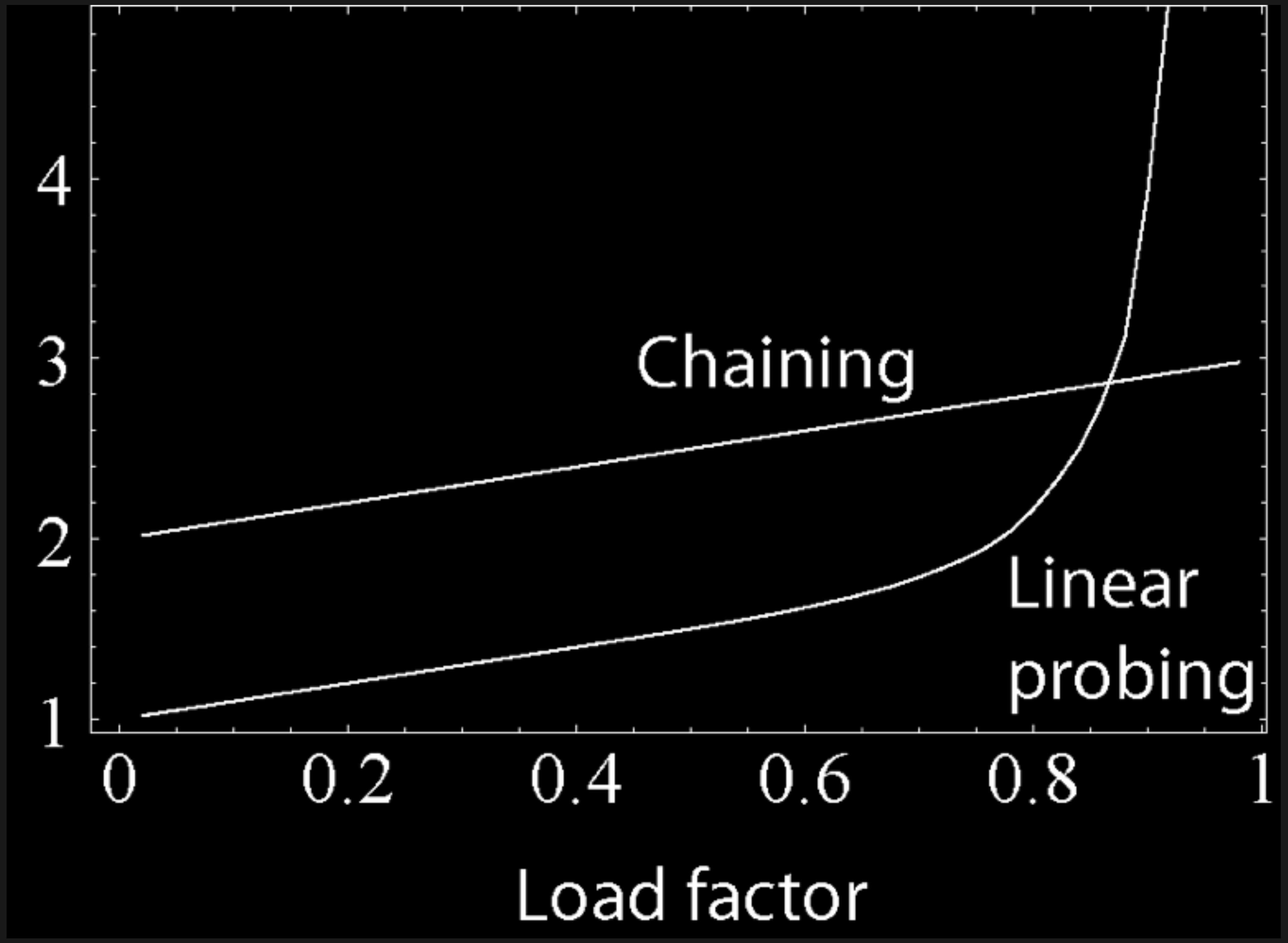
For **76** entries in a **128** bucket hash table,

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

LOAD FACTOR

Load factor affects performance

Collusion 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)

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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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