THE UNIVERSITY OF VERMONT
COLLEGE OF ENGINEERING &
MATHEMATICAL SCIENCES

Hash Tables: Quadratic Probing

CS 124 / Department of Computer Science

Quadratic probing

So far we've seen two collision resolution policies, separate chaining, and linear probing.

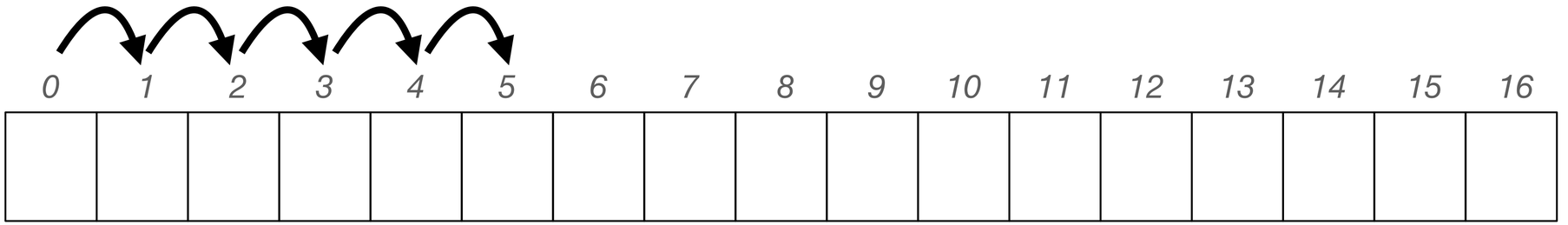
Quadratic probing is another approach to resolving hash collisions.

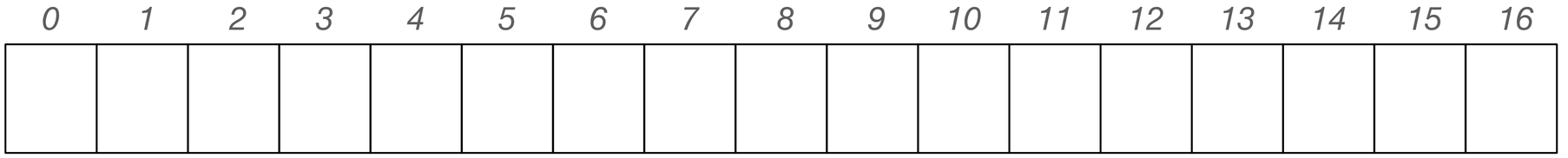
Quadratic probing

We've seen that linear probing is prone to primary clustering.

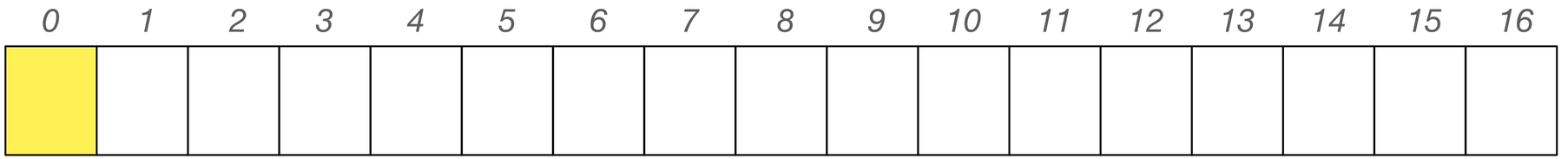
Quadratic probing is designed to eliminate primary clustering.

Quadratic probing vs linear probing

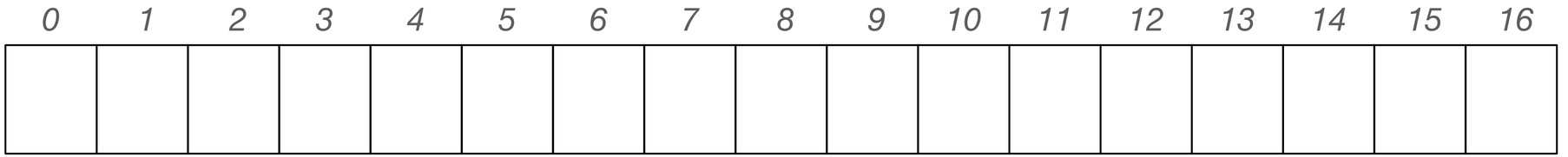




Quadratic probing vs linear probing



Insert at 0



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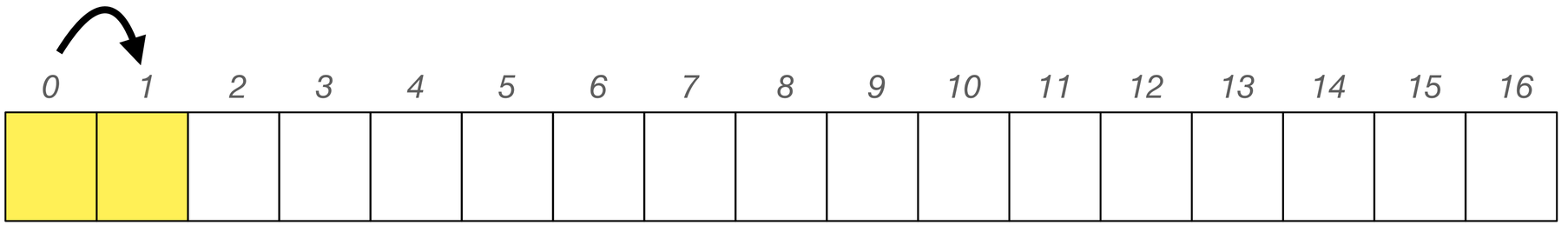
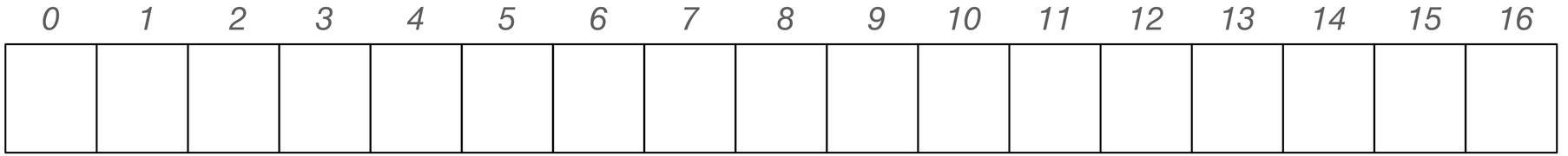
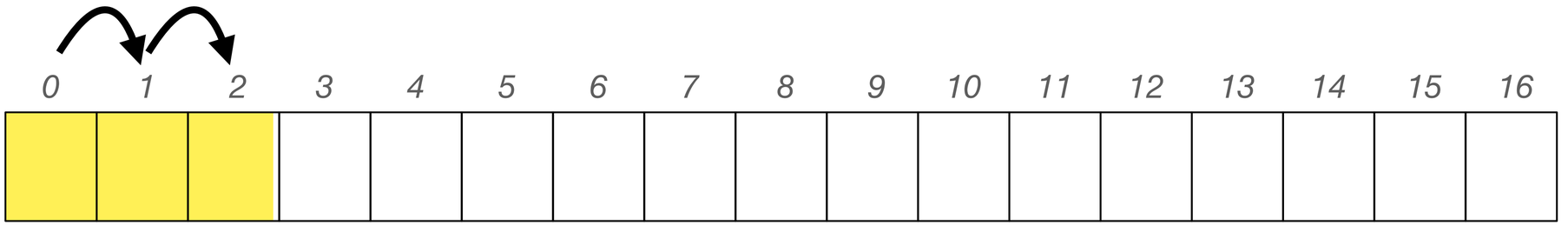


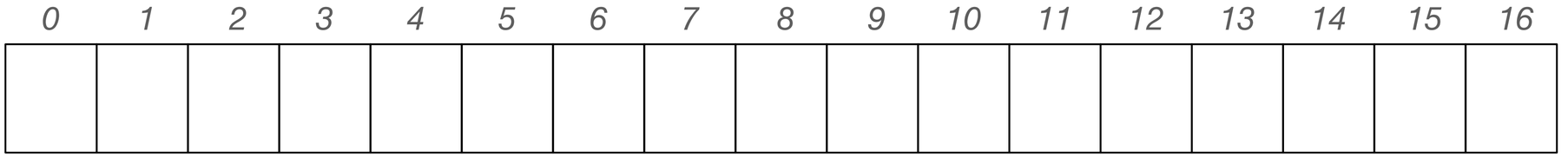
Insert at 0 or 1



Quadratic probing vs linear probing



Insert at 0, 1, or 2



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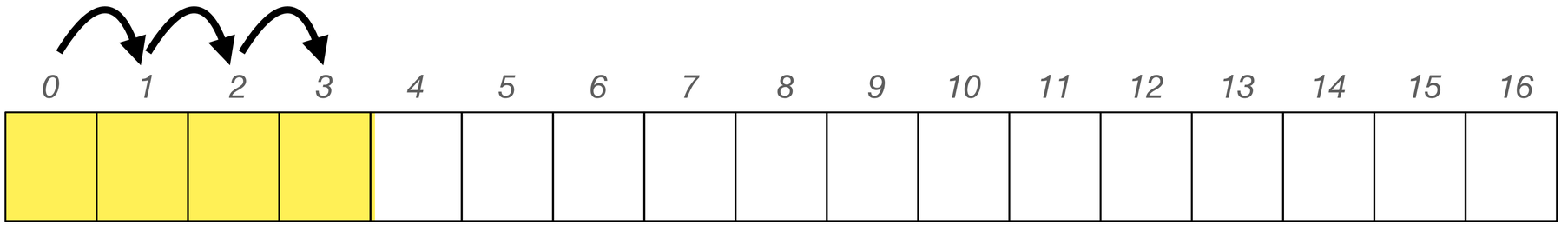
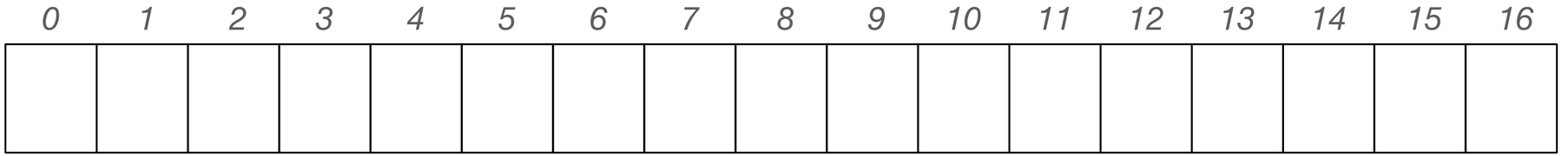


Insert at 0, 1, 2, or 3



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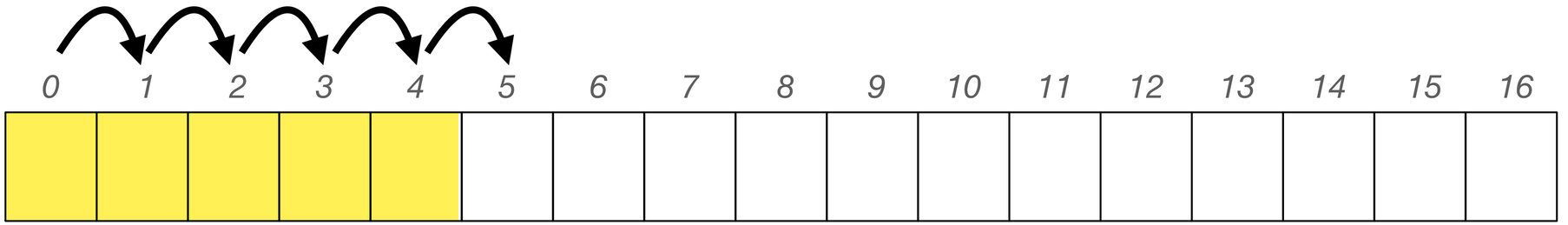
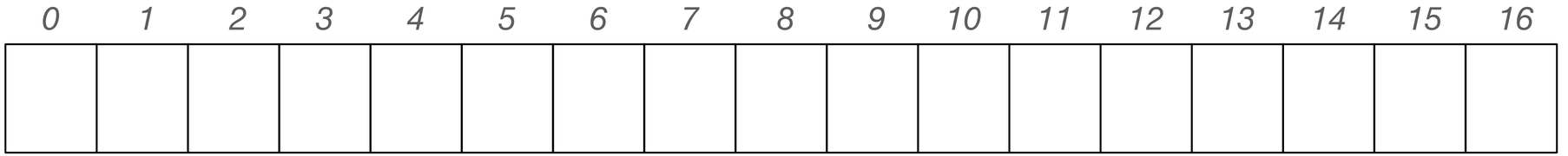
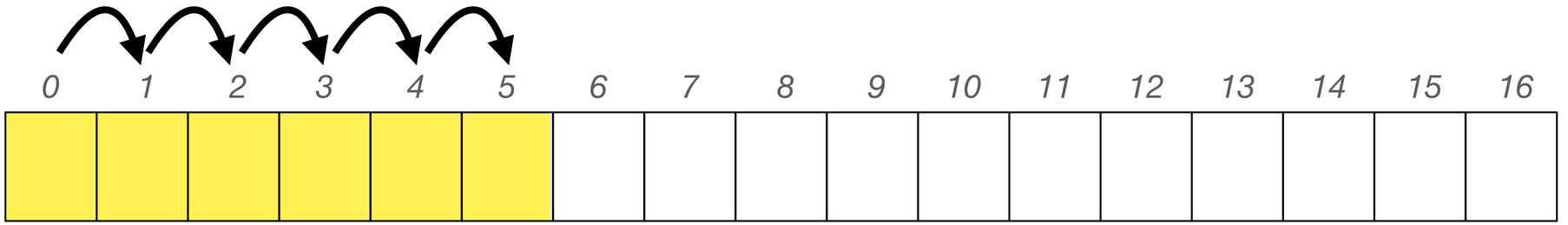


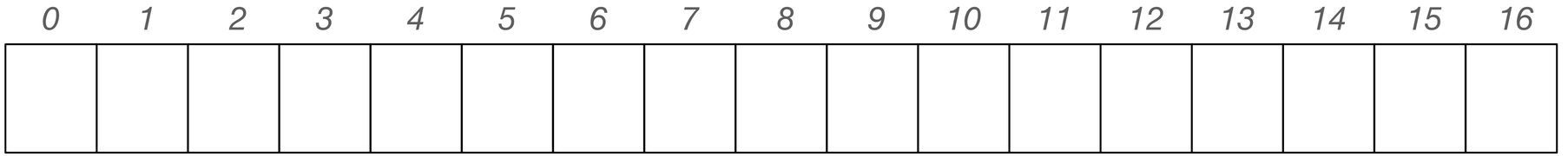
Insert at 0, 1, 2, 3 or 4



Quadratic probing vs linear probing



Insert at 0, 1, 2, 3, 4, or 5



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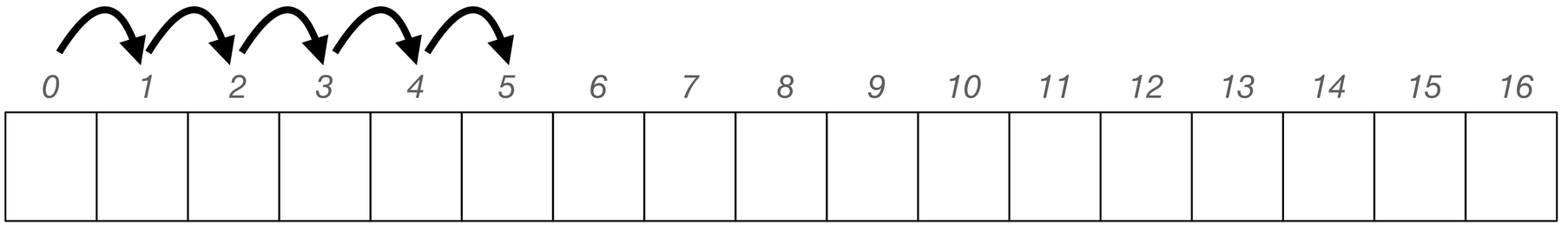

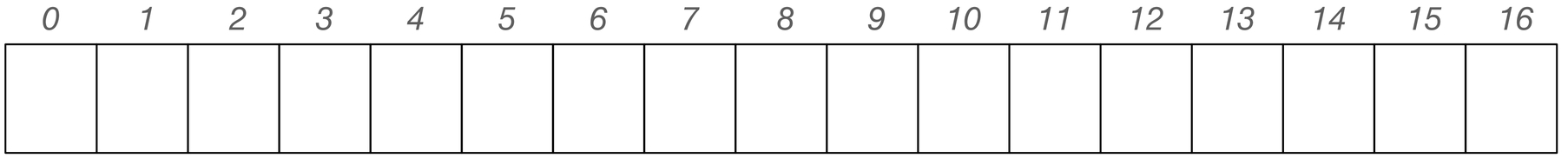

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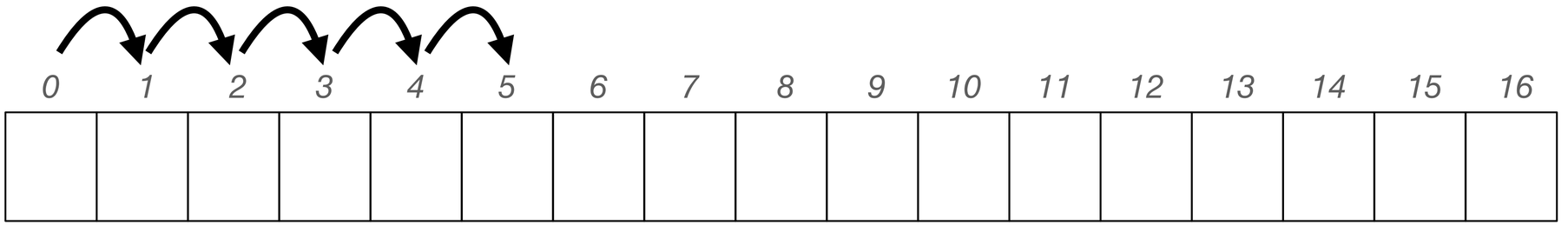
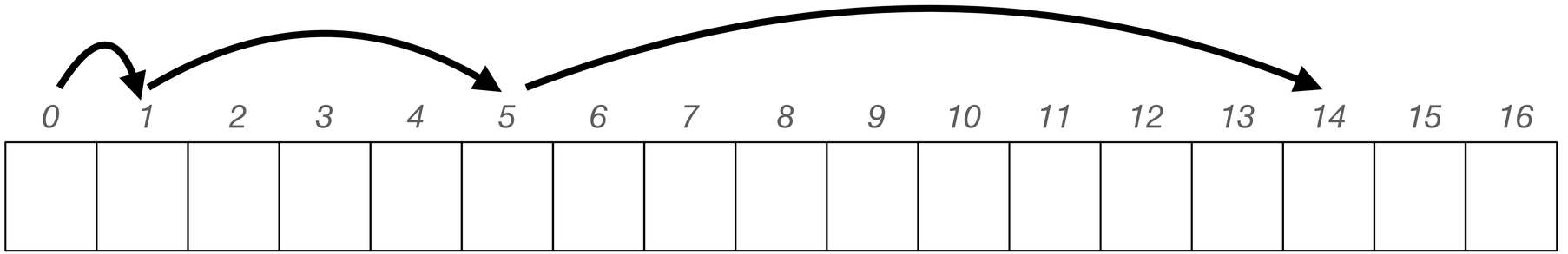
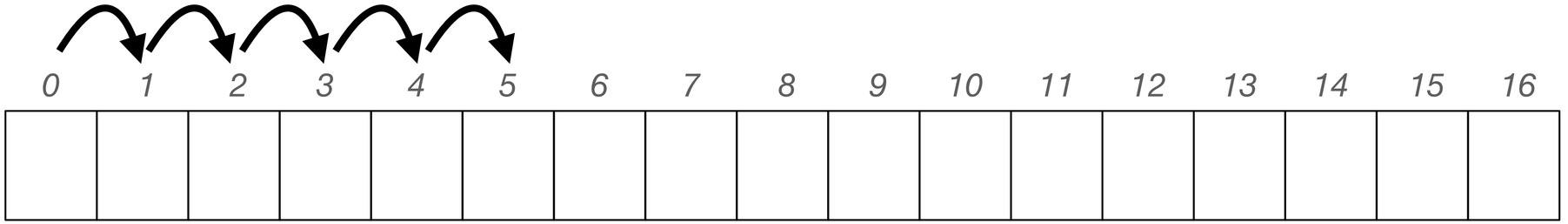


linear

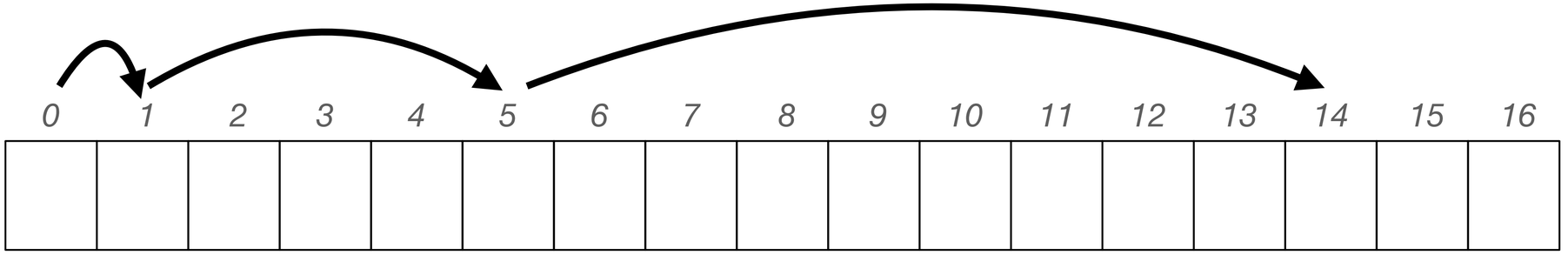


quadratic

Quadratic probing vs linear probing



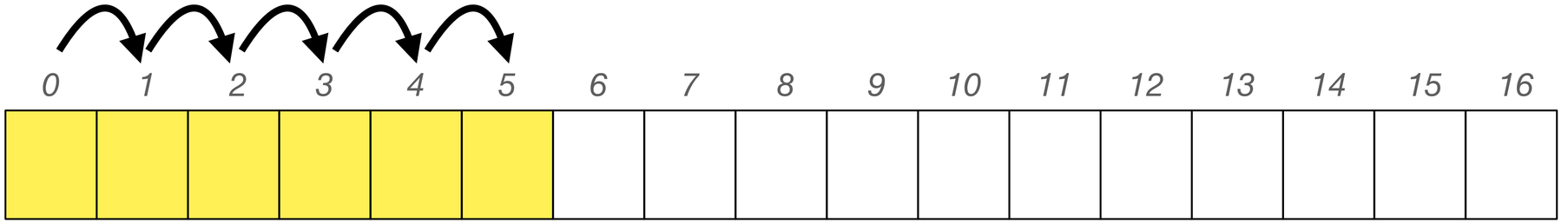
linear



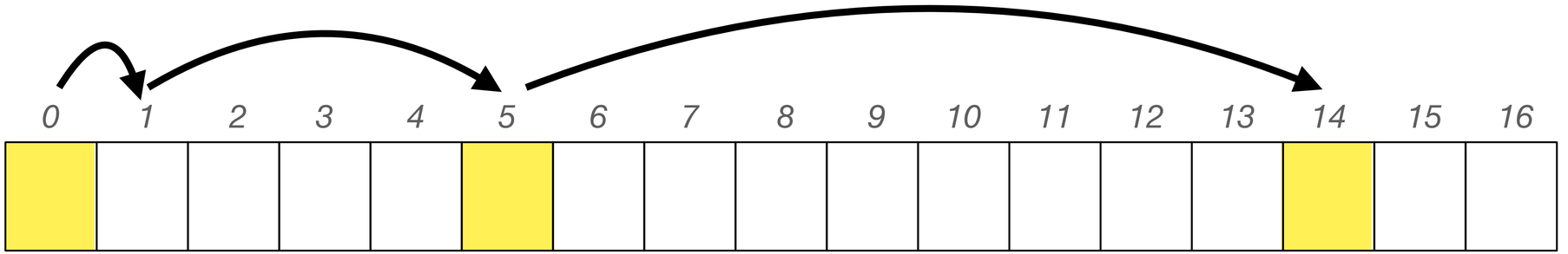
quadratic

$$1^2 = 1,\ 2^2 = 4,\ 3^2 = 9,\ 4^2 = 16, \ldots$$

Quadratic probing vs linear probing



primary clustering



secondary clustering

Comparison of CRPs

Linear probing	Quadratic probing	Separate chaining
On collisions we probe		On collisions we extend the chain
Fixed upper limit on number of objects we can insert (size of hash table)		Only limited by memory / system constrants
Fixed stride (typically 1)	Stride changes on each step ($step^2$)	n/a
Prone to primary clustering	Prone to secondary clustering	Clustering does not occur

Quadratic probing: summary

- Like linear probing, and unlike separate chaining, we only allow a single object at a given index.
- Upon hash collisions, we probe our hash table, one step at a time, until we find an empty position in which we may insert our object -- but our stride changes on each step:

$$1^2 = 1,\ 2^2 = 4,\ 3^2 = 9,\ 4^2 = 16, \ldots$$

- Like linear probing, and unlike separate chaining, quadratic probing has a fixed limit on the number of objects we can insert into our hash table.