The Dictionary

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(   )

$$\begin{array}{c}
() \\
* \quad (\quad \&) \\
(\quad \&) \\
(\quad \&)
\end{array}$$

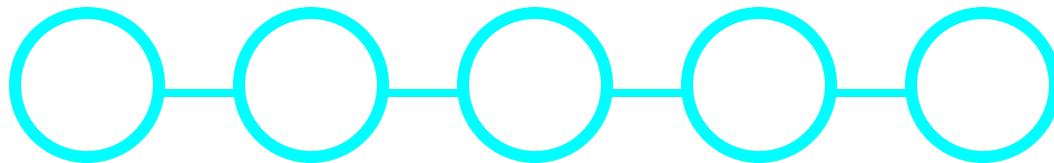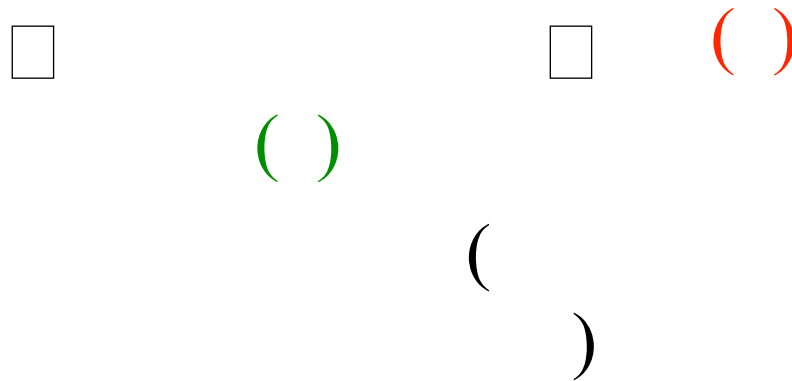# Implementing a Dictionary with a Sequence

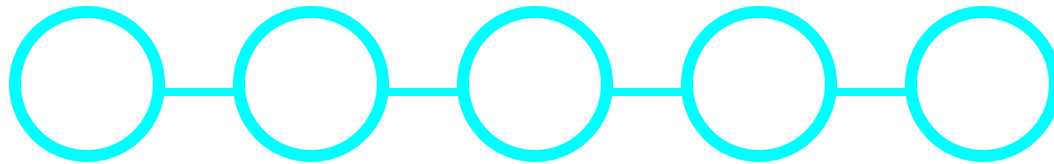# Implementing a Dictionary with a Sequence

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(   )   □

                      (   )   (   )

                                ( )   □

(□)

( ) → ( )

(   )

n

R

e   k

A[k]

( )	( )				( )

A

( )

( )

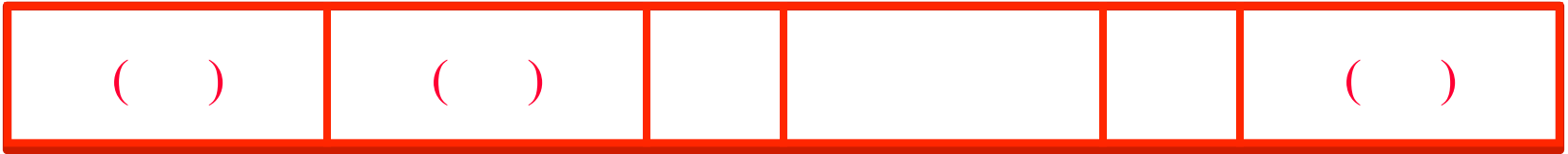– O(n) for linear searches
– O (log$n$) for binary search
– O(1) for hash table

Space Solution

A

( )   (n

)   N

(   )

(
)
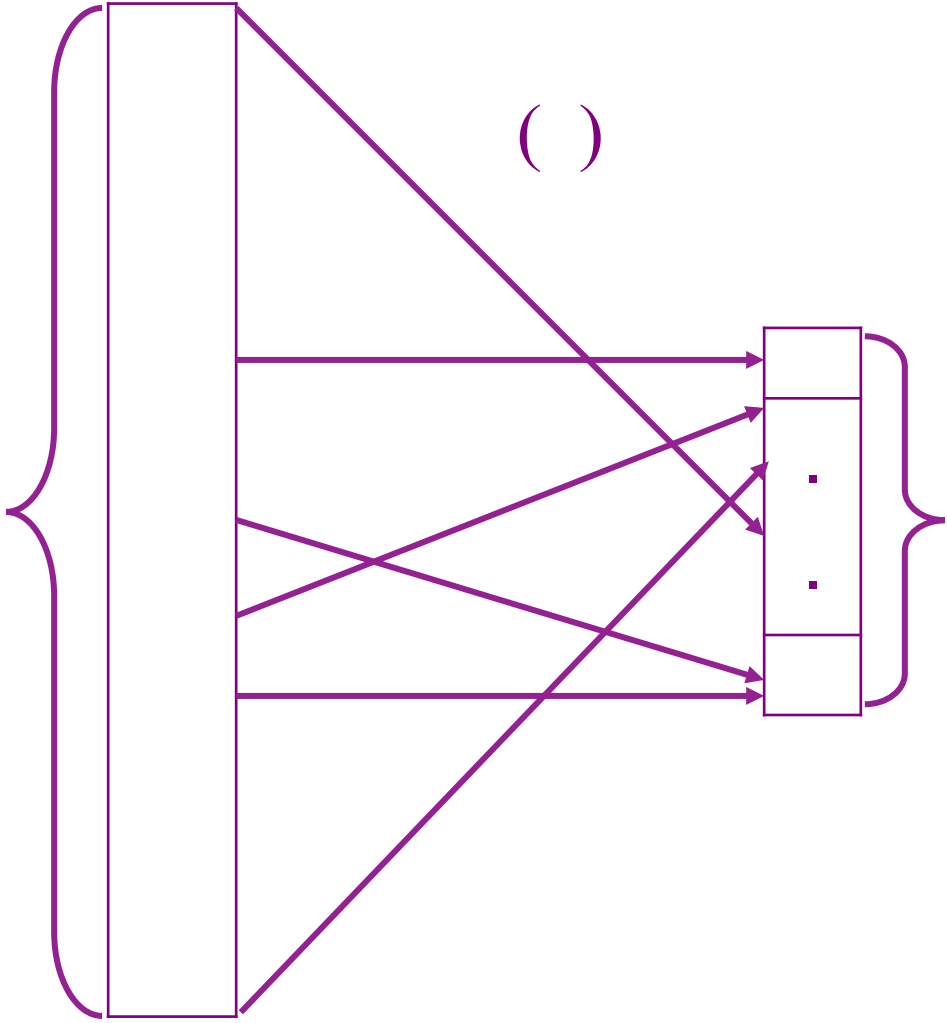
ht

ht **b**

ht

s

$(\ )$

$(\ ) \in$

T

n

key density   **n/T**

synonyms

$h(k1) = h(k2).$

collision

overflow

$$\alpha$$

$$(\ )$$

ht	Slot 1	Slot 2
0	A	
1		
2		
3	D	
4		
5		
6	GA	G
.	.	.
.	.	.
25		

n

From Keys to Indices

hash function

hash code map ◊ integer
compression map integer ◊

Hash function

equal keys to equal indices
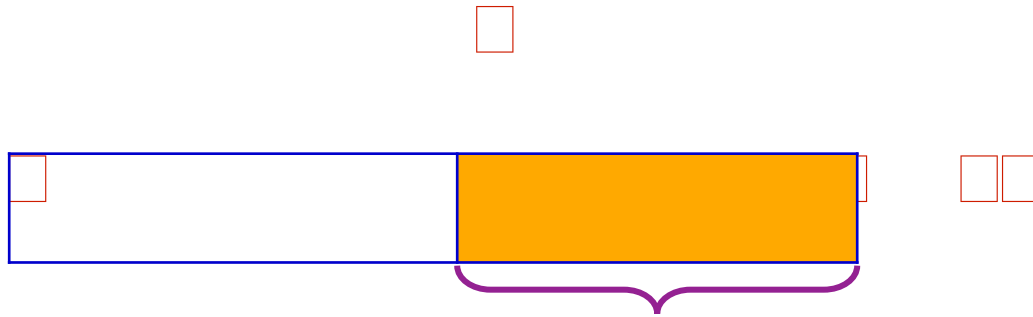
probability of collisions

Easy to compute

( )

compression map

$(\quad) \quad | \quad \textbf{mod } N$

$N \quad ^r$ ☐

k ☐☐

N   **prime**

number

hash code map

( )

k^2

hash code map

- Folding

( )

( )

hash code map

$$(\qquad)$$

$$a \ a \ \ldots a$$

$$a + a \ x$$

$$+ \ldots + x \quad a$$

!
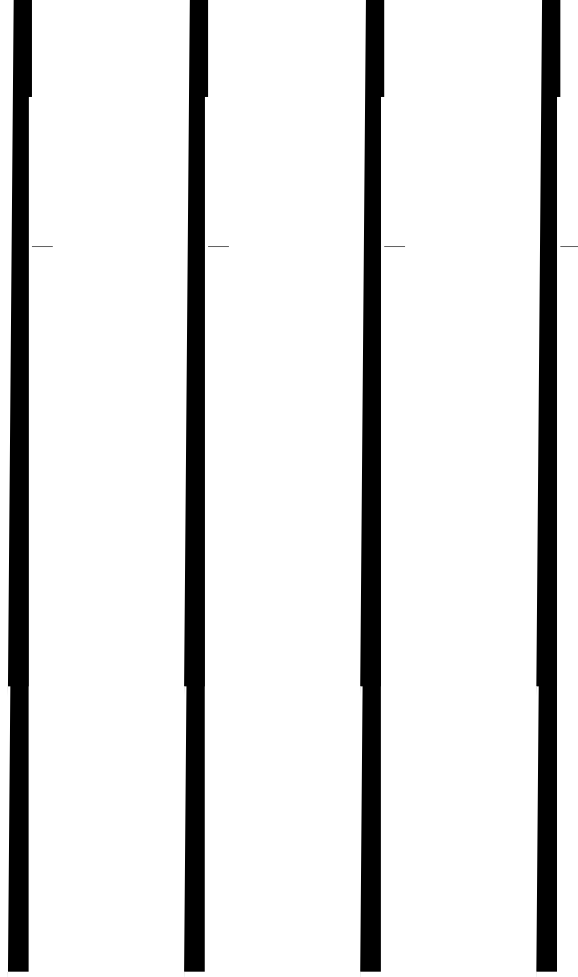
A

C
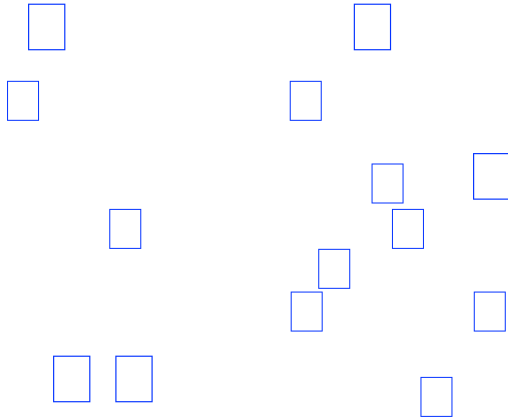
$$h_i(K) = (hash(K) + i) \bmod m$$

( )

(( )   )

$$h_i(K) = (hash(K) + i^2) \bmod m$$

( )

(( )   )

0 0 0

Hash (key) produces
an index in the range
0 to 6. That index is
the "home address"

Some insertions:
K1 --> 3
K2 --> 5
K3 --> 2

	key	value
0		
1		
2	K3	K3info
3	K1	K1info
4		
5	K2	K2info
6		

Some more insertions:
K4 --> 3
K5 --> 2
K6 --> 4

Linear probing collision
resolution strategy

0	K6	K6info
1		
2	K3	K3info
3	K1	K1info
4	K4	K4info
5	K2	K2info
6	K5	K5info

0	K6	K6info
1		
2	K3	K3info
3	K1	K1info
4	K4	K4info
5	K2	K2info
6	K5	K5info

Average number of probes needed to retrieve the value with key K?

K	hash(K)	#probes
K1	3	1
K2	5	1
K3	2	1
K4	3	2
K5	2	5
K6	4	4

14/6 = 2.33 (successful)

insert keys:

K1 --> 3

K2 --> 5

K3 --> 2

K4 --> 3

K5 --> 2

K6 --> 4

0	↓
1	↓
2	↓ → K3 K3info → K5 K5info
3	↓ → K1 K1info → K4 K4info
4	↓ → K6 K6info
5	↓ → K2 K2info
6	↓

linked lists of synonyms
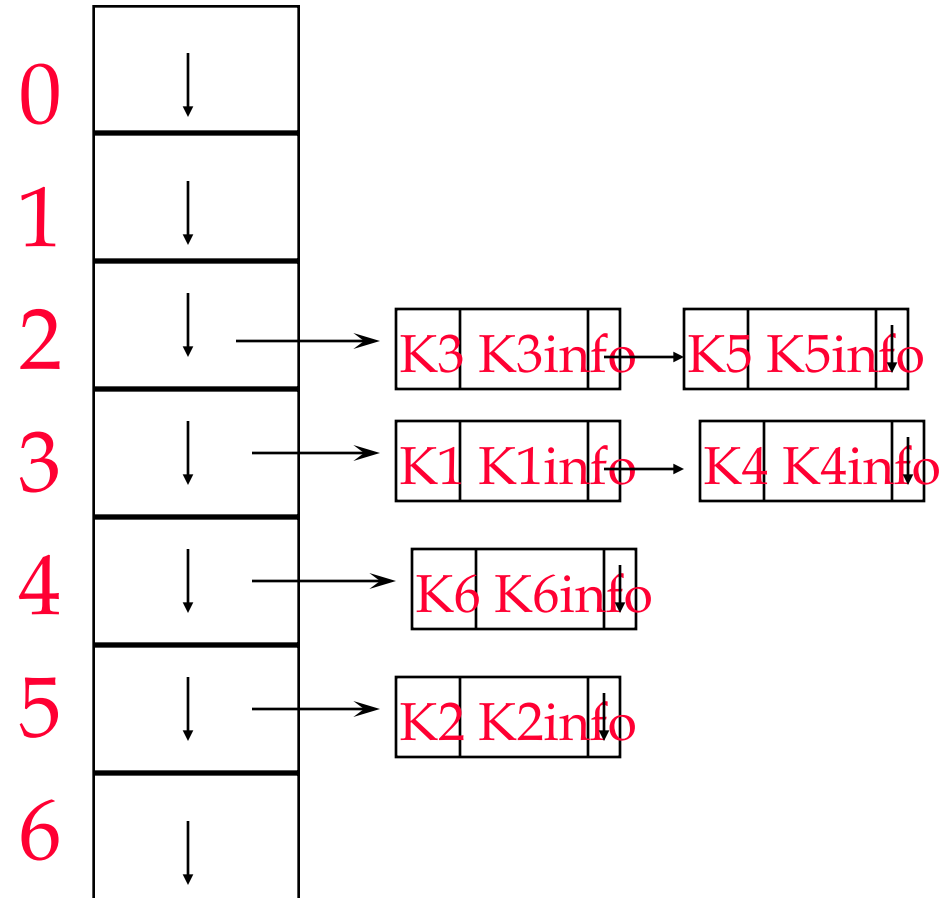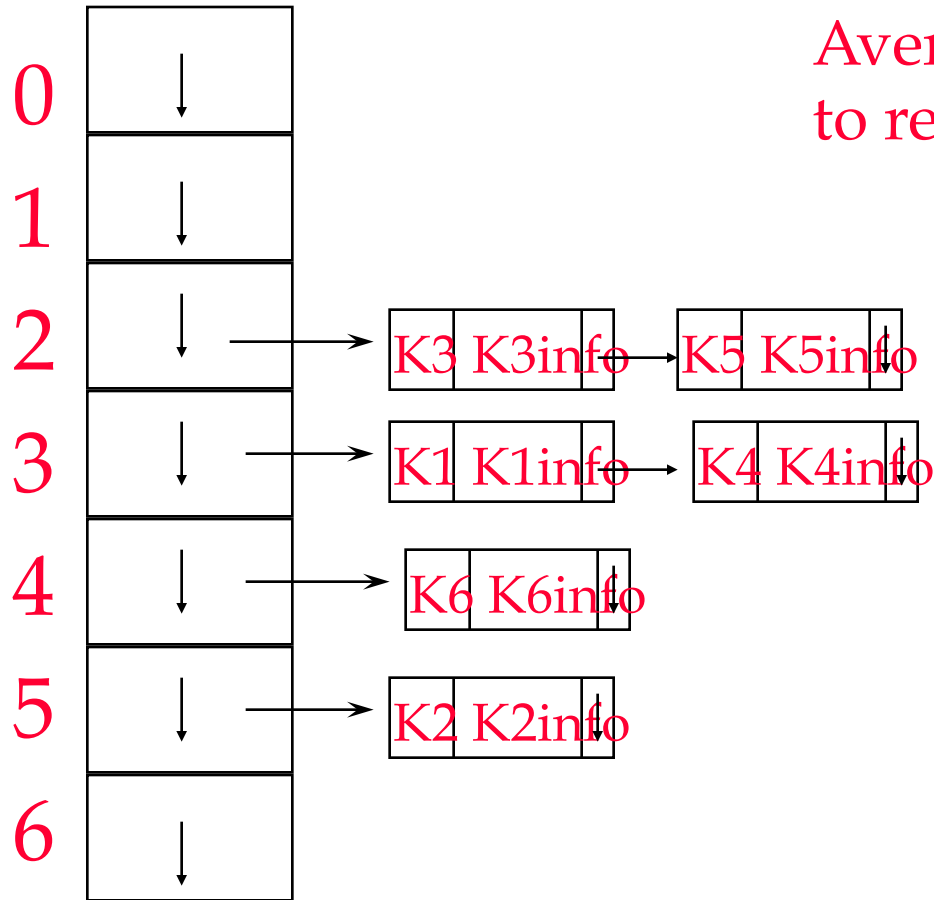
0

1

2 ——→ | K3 | K3info | ——→ | K5 | K5info |

3 ——→ | K1 | K1info | ——→ | K4 | K4info |

4 ——→ | K6 | K6info |

5 ——→ | K2 | K2info |

6

Average number of probes needed
to retrieve the value with key K?

K	hash(K)	#probes
K1	3	1
K2	5	1
K3	2	1
K4	3	2
K5	2	2
K6	4	1

8/6 = 1.33 (successful)

load factor	open addressing (linear probing)	open addressing (double hashing)	chaining
0.5	1.50	1.39	1.25
0.7	2.17	1.72	1.35
0.9	5.50	2.56	1.45
1.0	----	----	1.50
2.0	----	----	2.00