



UNIVERSITY OF TORONTO
FACULTY OF ENGINEERING
SCIENCE & MATHEMATICS

Hash Tables

Hashing

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hash tables.

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Hashing

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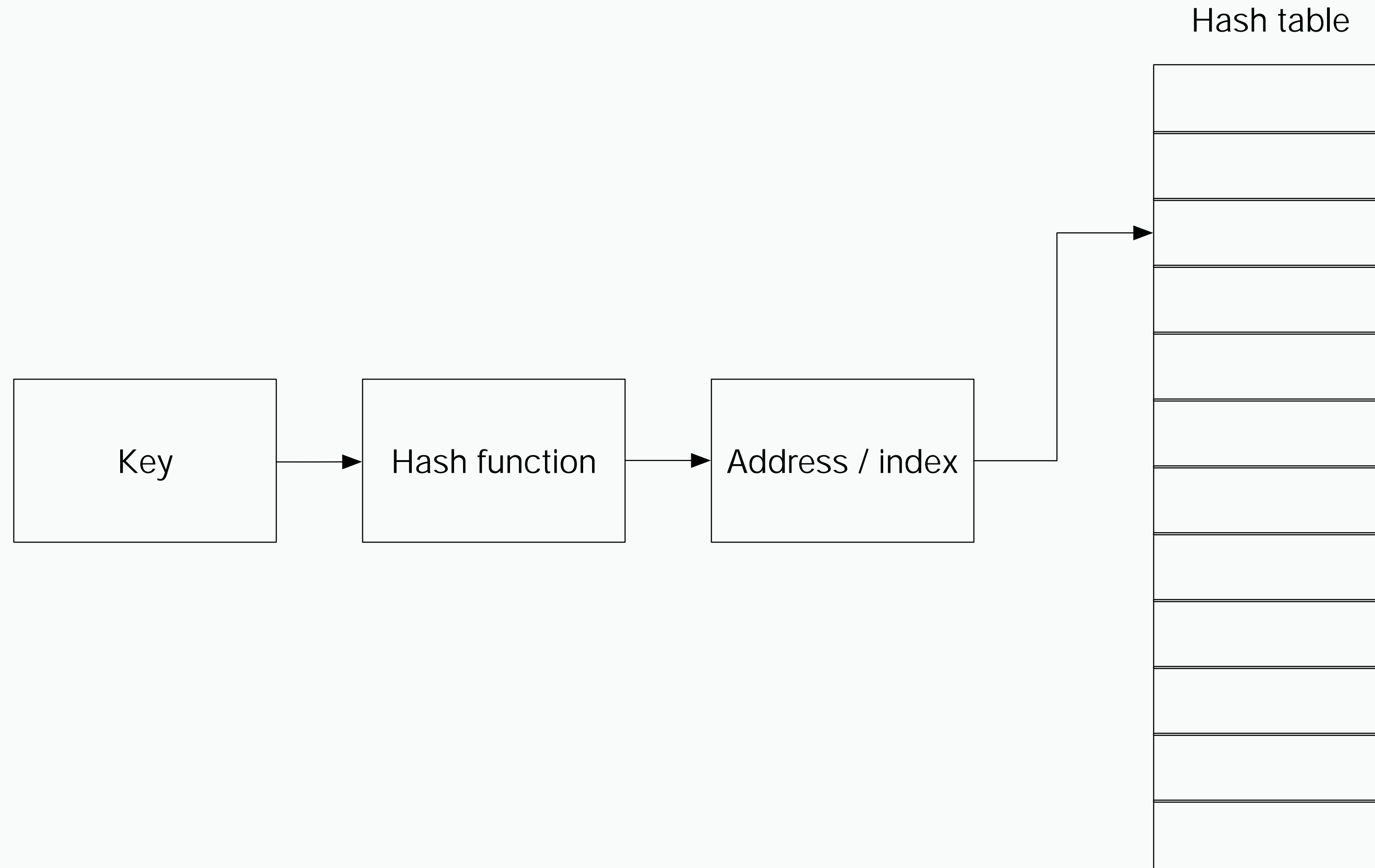
Motivation

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Hashing

*A hash table stores items in a way
that lets you find the item's
index .*

A hash function is a map



Choosing a size for our hash table

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Choosing a hash function

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- $.$
- $.$
- $.$
- 0
- $- 1.$
- ff

Choosing a hash function

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A not-so-good hash function

```
int notSoGoodHash(std::string s, int maxIndex) {  
    int hash = 0;  
    for (const char& c : s) {  
        hash = hash + c;  
    }  
    return hash % maxIndex;  
}
```

10
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5
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A better hash function

```
unsigned long betterHash(std::string s, int maxIndex) {  
    unsigned long hash = 0;  
    for (const char& c : s) {  
        hash = hash * 37 + c;  
    }  
    return hash % maxIndex;  
}
```

11
9
12
3
3
14
7

Horner hash function

```
unsigned long hornerHash(std::string s, int maxIndex) {  
    unsigned long hash = 0;  
    for (const char& c : s) {  
        hash = hash * 37 + c;  
    }  
    return hash % maxIndex;  
}
```


Horner hash function

```
unsigned long hornerHash(std::string s, int maxIndex) {  
    unsigned long hash = 0;  
    for (const char& c : s) {  
        hash = hash * 37 + c;  
    }  
    return hash % maxIndex;  
}
```

|| ||

$$\begin{aligned} & (37 \quad) + \\ & 37 \quad ((37 \quad) + \quad) + \\ & 37 \quad (37 \quad ((37 \quad) + \quad) + \quad) + \end{aligned}$$

$$= 37$$

Choosing a hash function

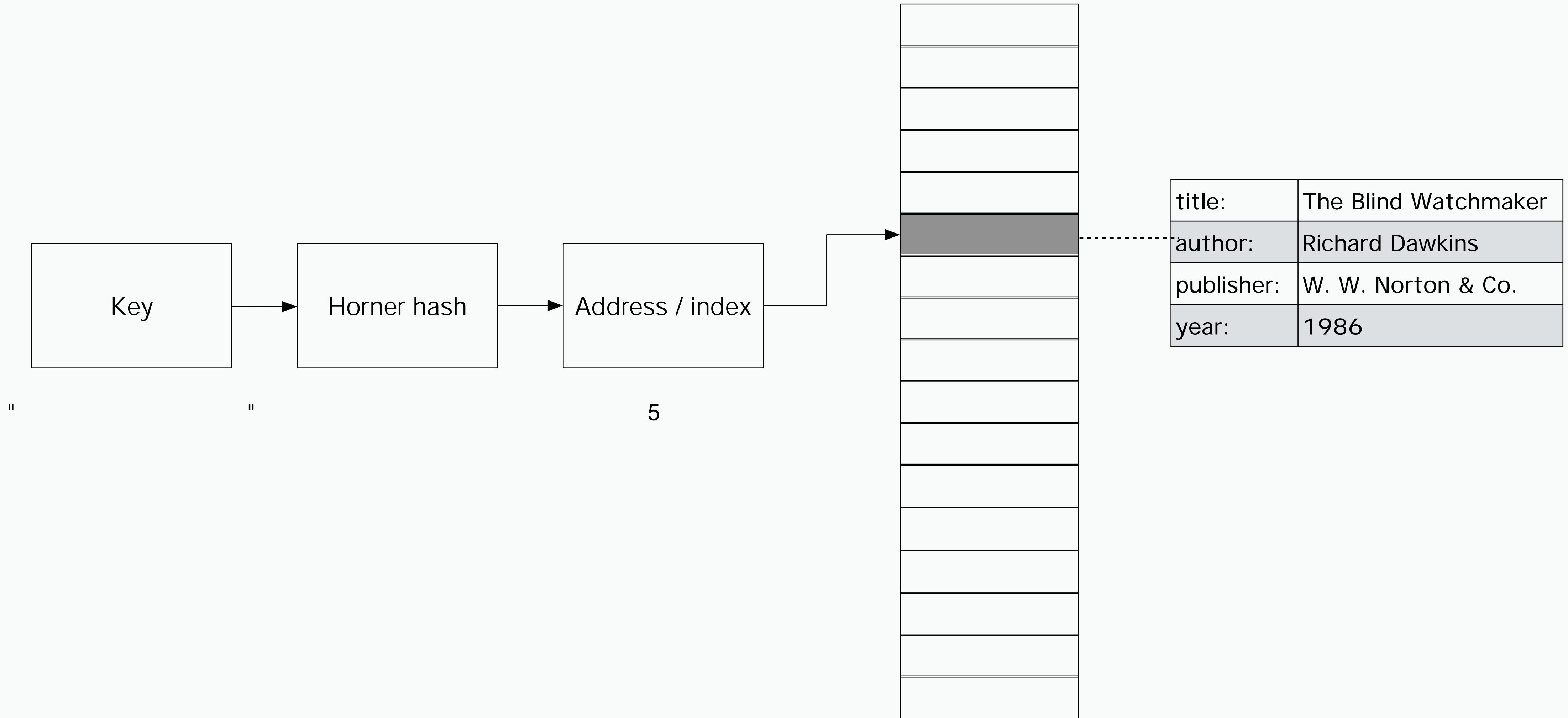
- $(, ,)$
- $.$
- $.$
- $.$
- $0 - 1.$

Inserting

title:

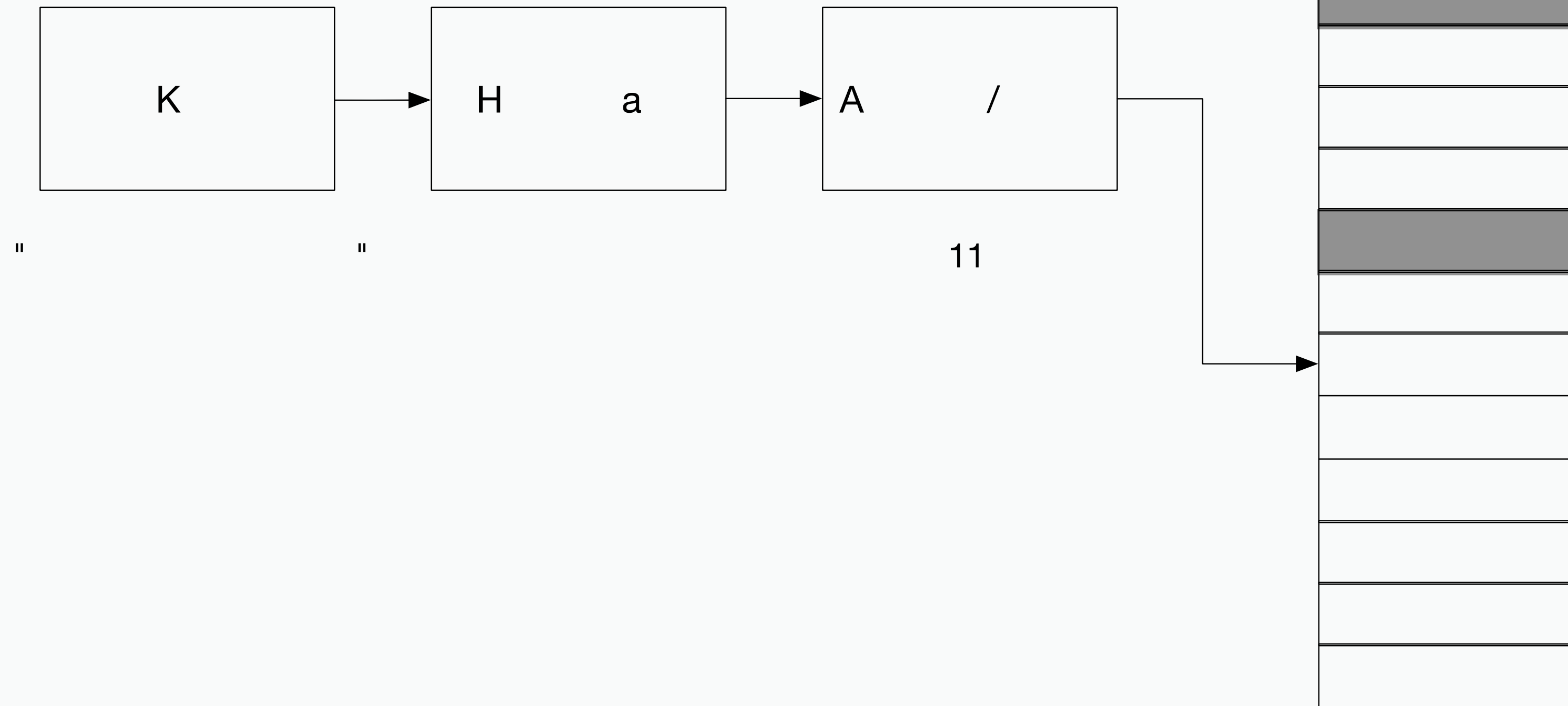
Inserting

Hash table

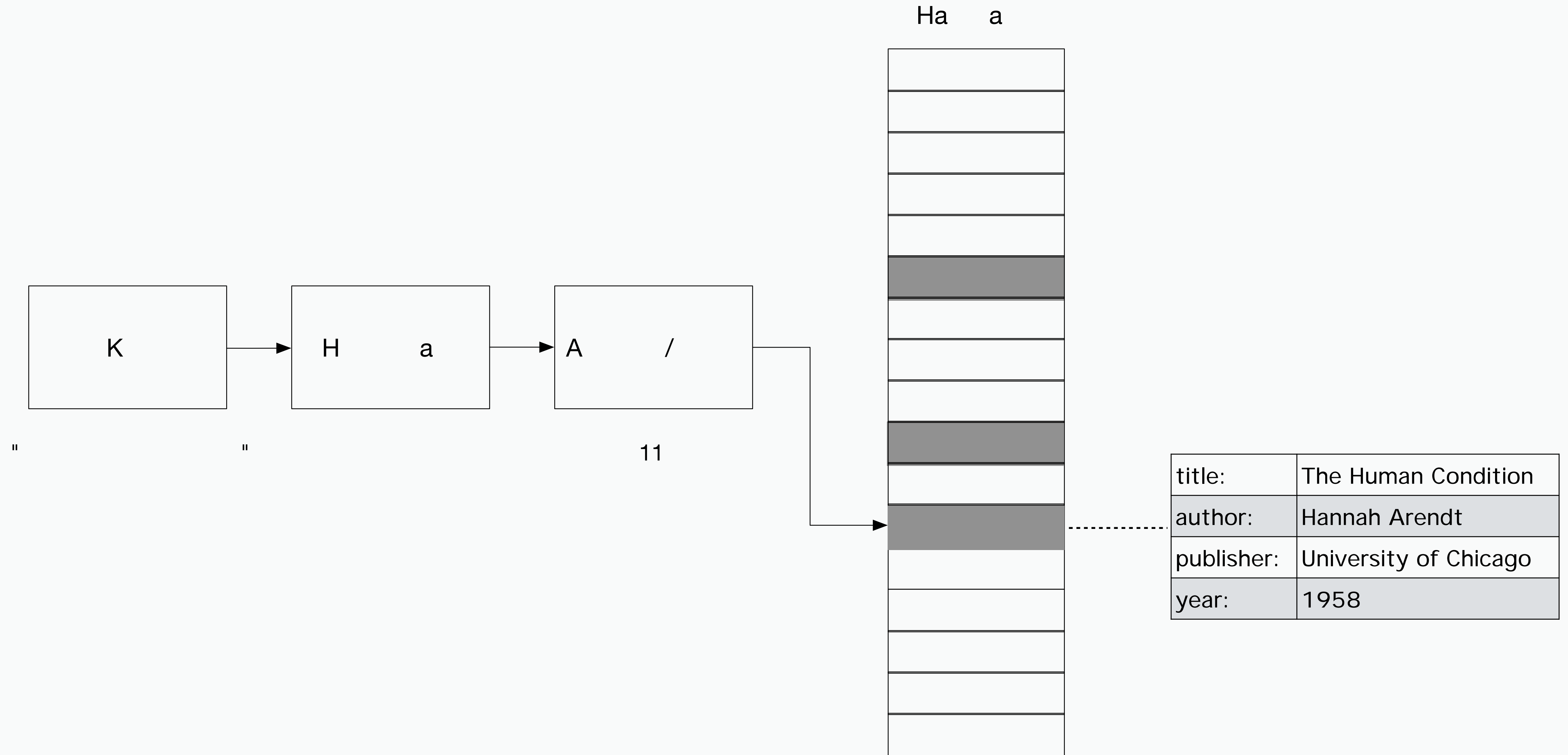


Inserting

title:	The Human Condition
author:	Hannah Arendt
publisher:	University of Chicago
year:	1958

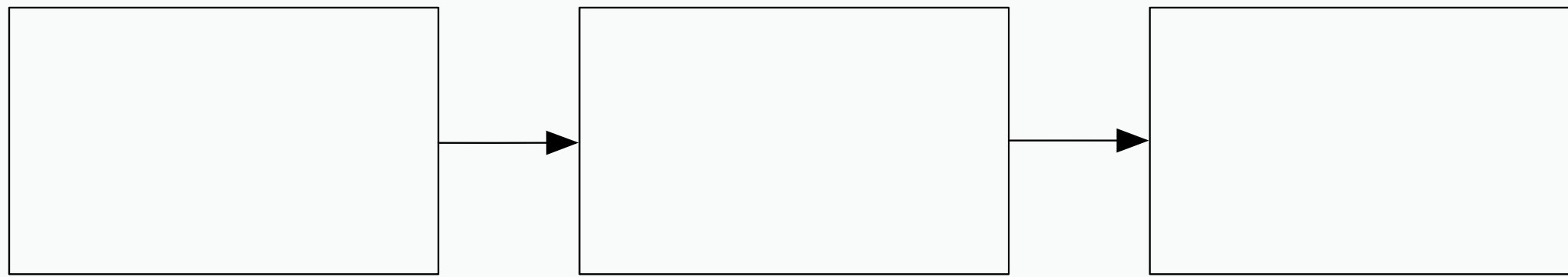


Inserting



Inserting

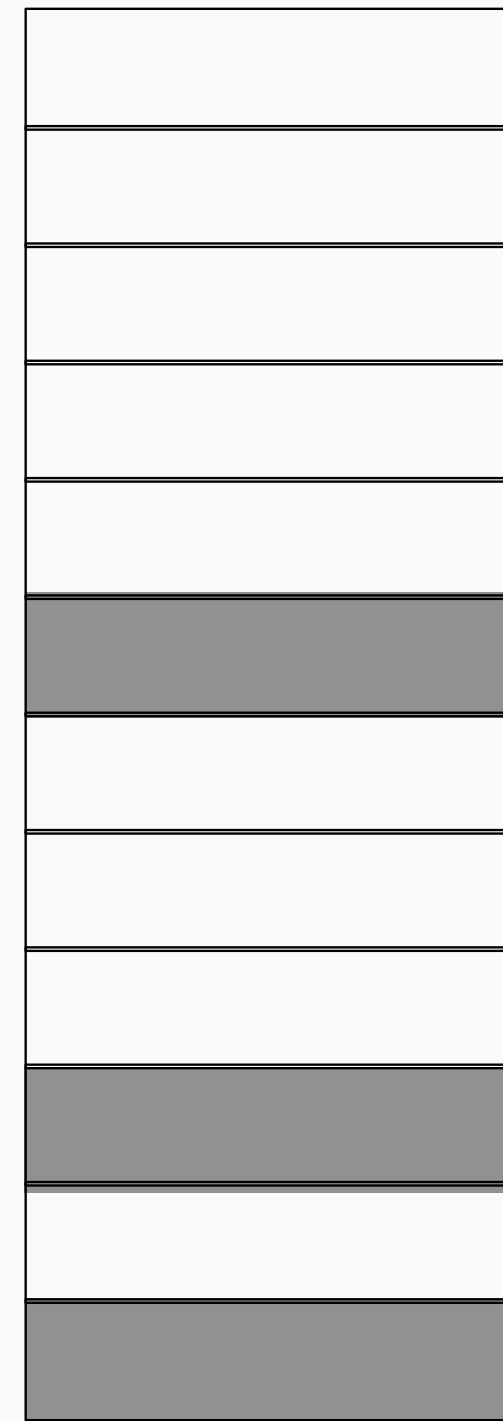
title:	Modern Algebra
author:	John R. Durbin
publisher:	John Wiley & Sons
year:	1992



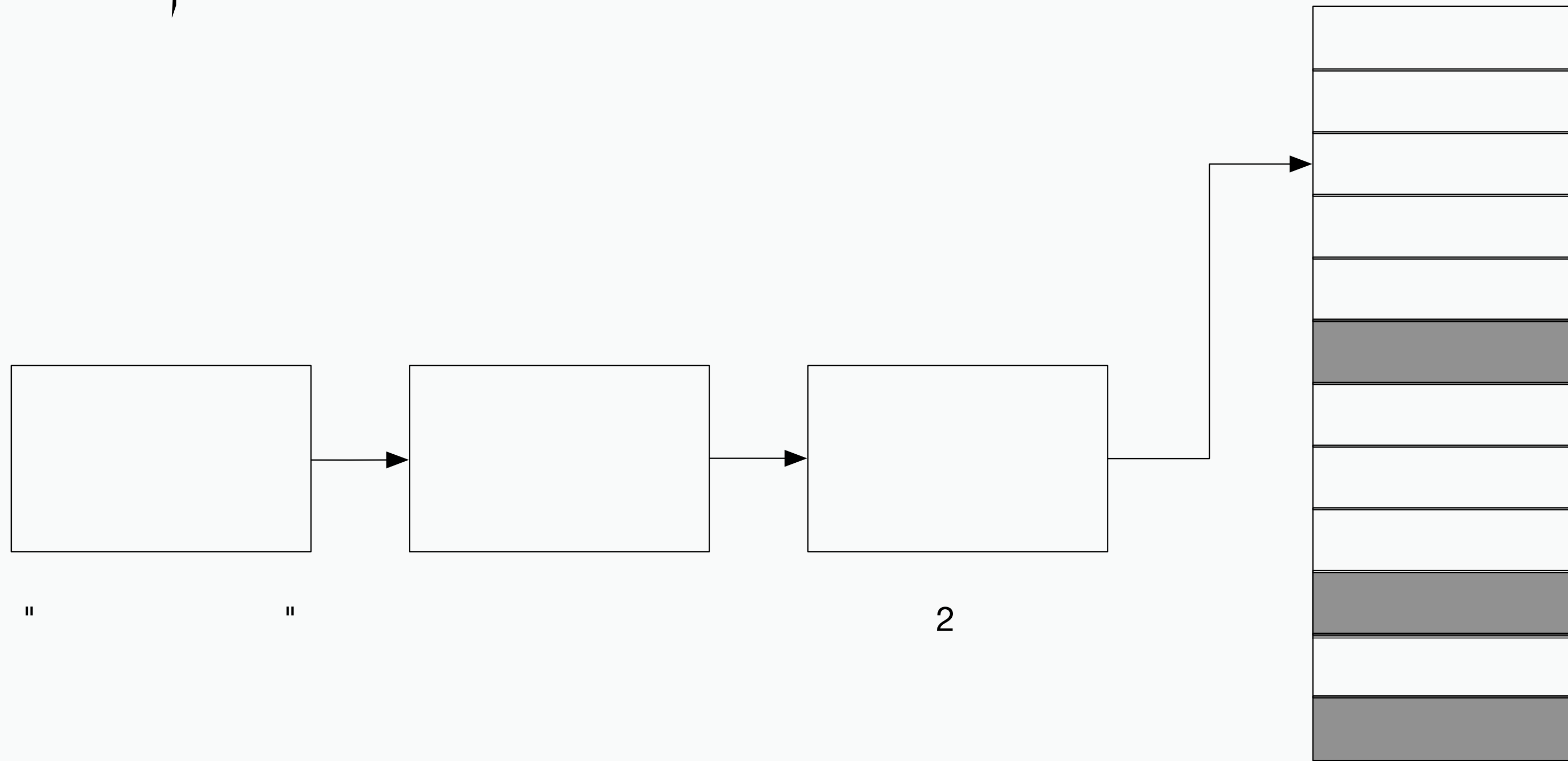
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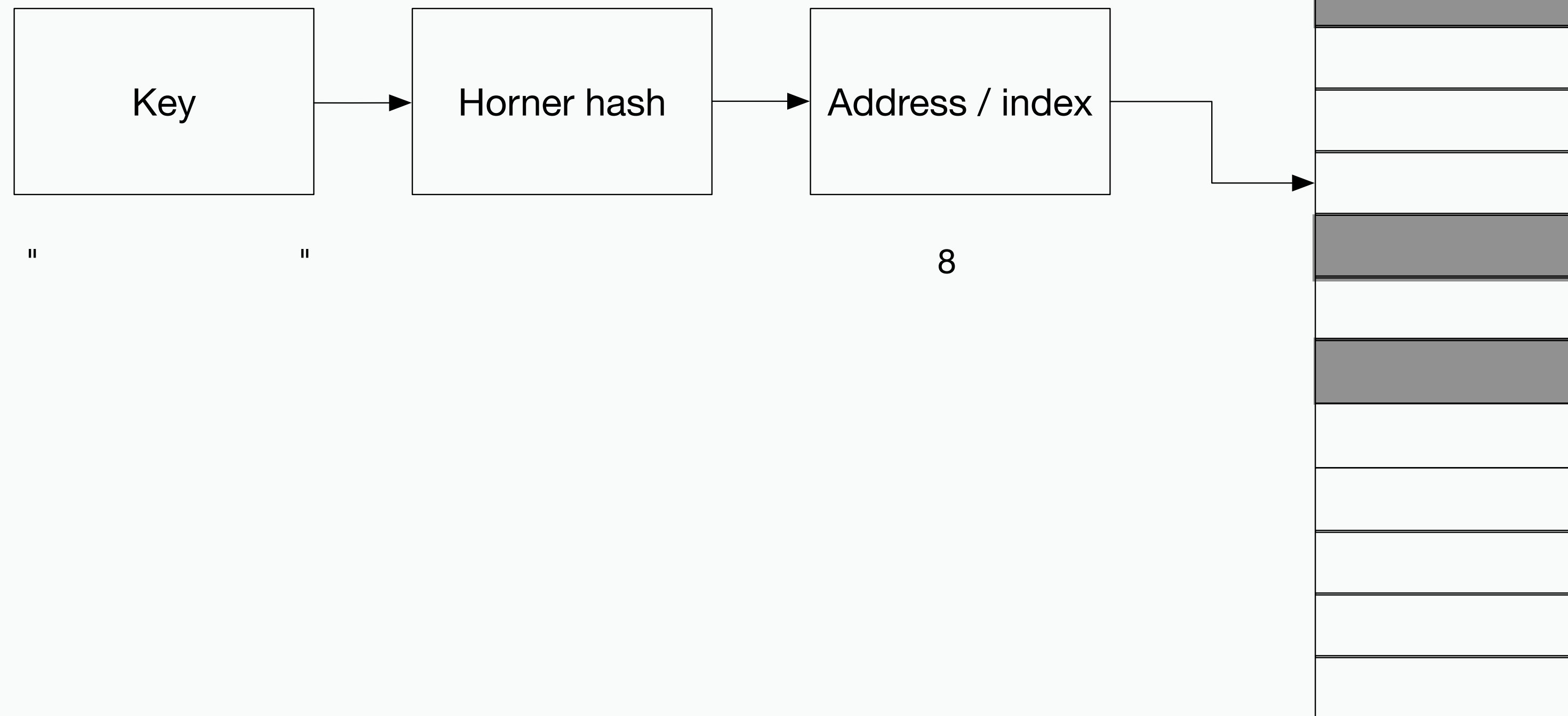
Inserting



title:	Modern Algebra
author:	John R. Durbin
publisher:	John Wiley & Sons
year:	1992

Inserting

title:	Symbiotic Planet
author:	Lynn Margulis
publisher:	Basic Books
year:	1999

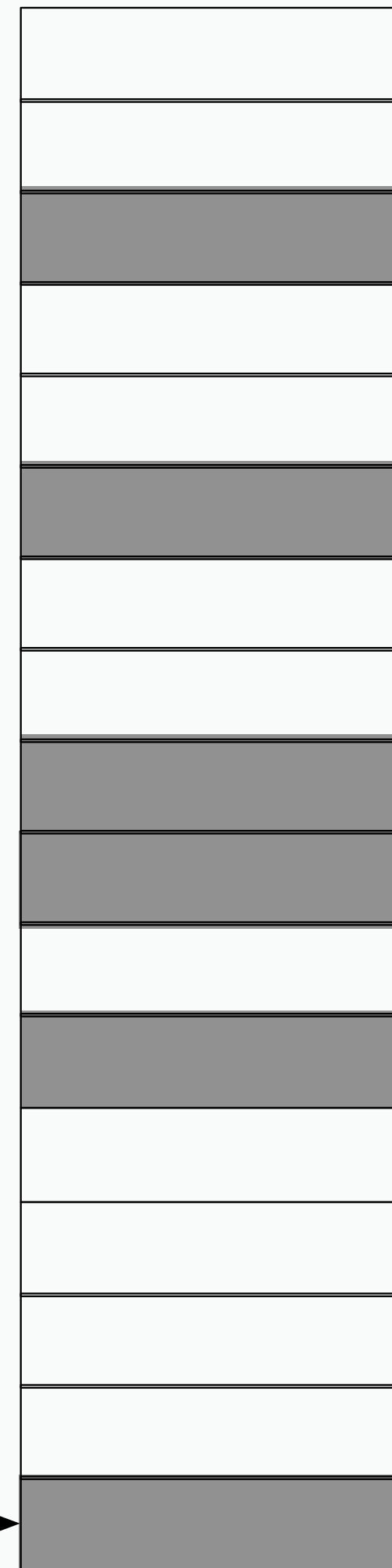


Inserting

title:	You Are Not A Gadget
author:	Jaron Lanier
publisher:	Basic Books
year:	1999

Inserting

Hash table



title:	You Are Not A Gadget
author:	Jaron Lanier
publisher:	Basic Books
year:	1999

Key

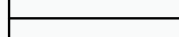
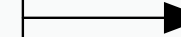
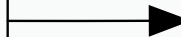
Horner hash

Address / index

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Inserting - what's the complexity?

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Inserting - what's the complexity?

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$O(1)$

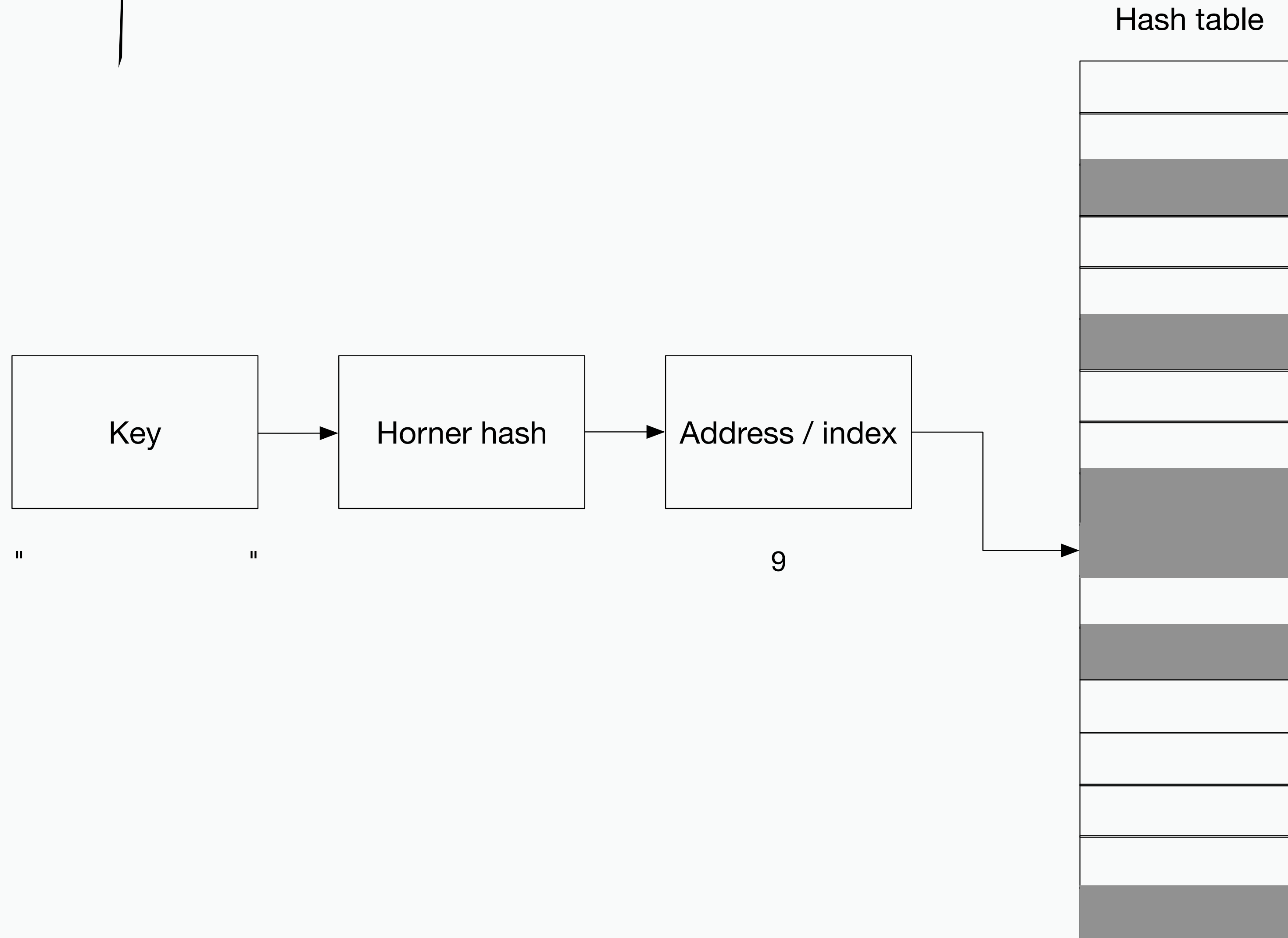
Finding

title: The Blind Watchmaker

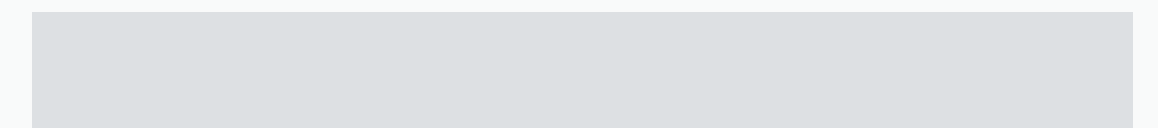
author: Richard Dawkins

publisher:

Finding



Finding



Finding

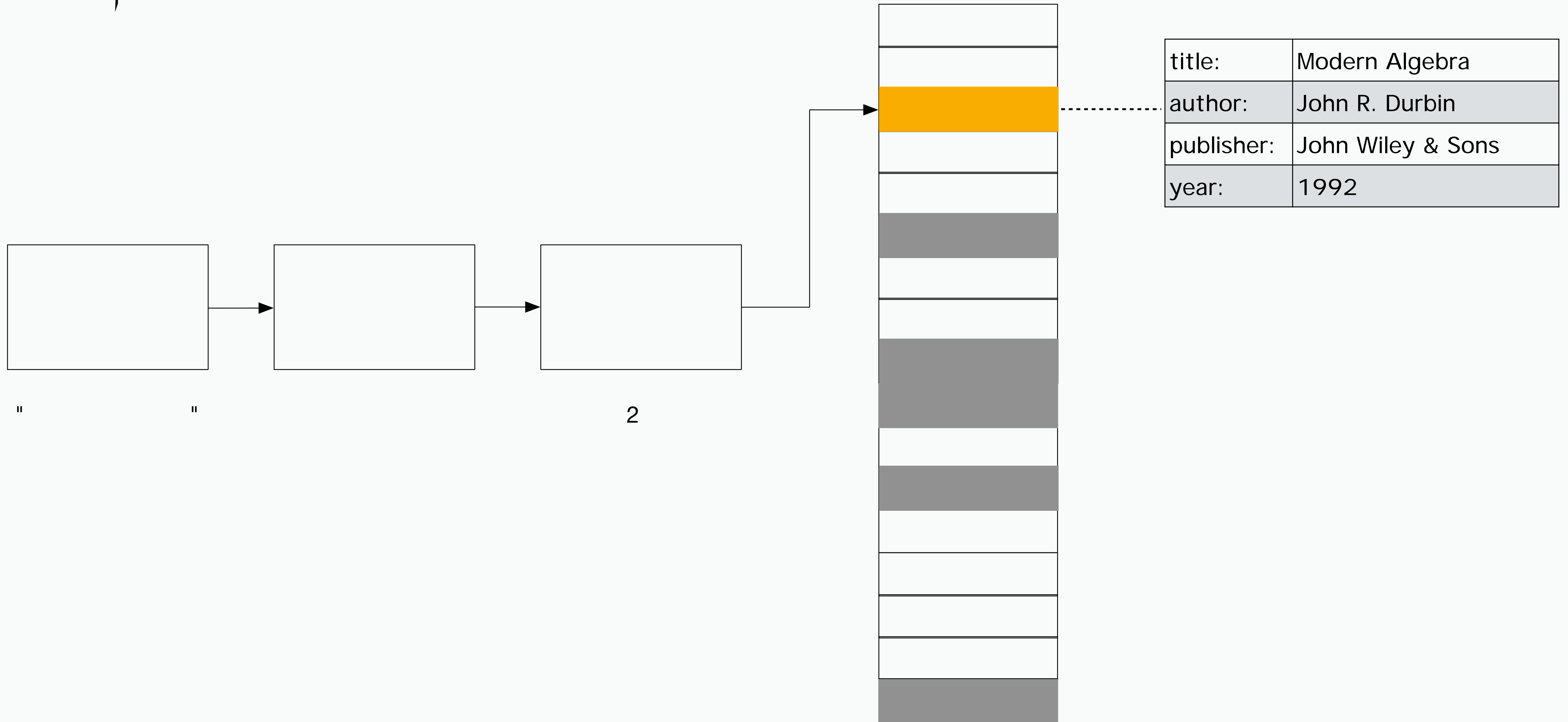


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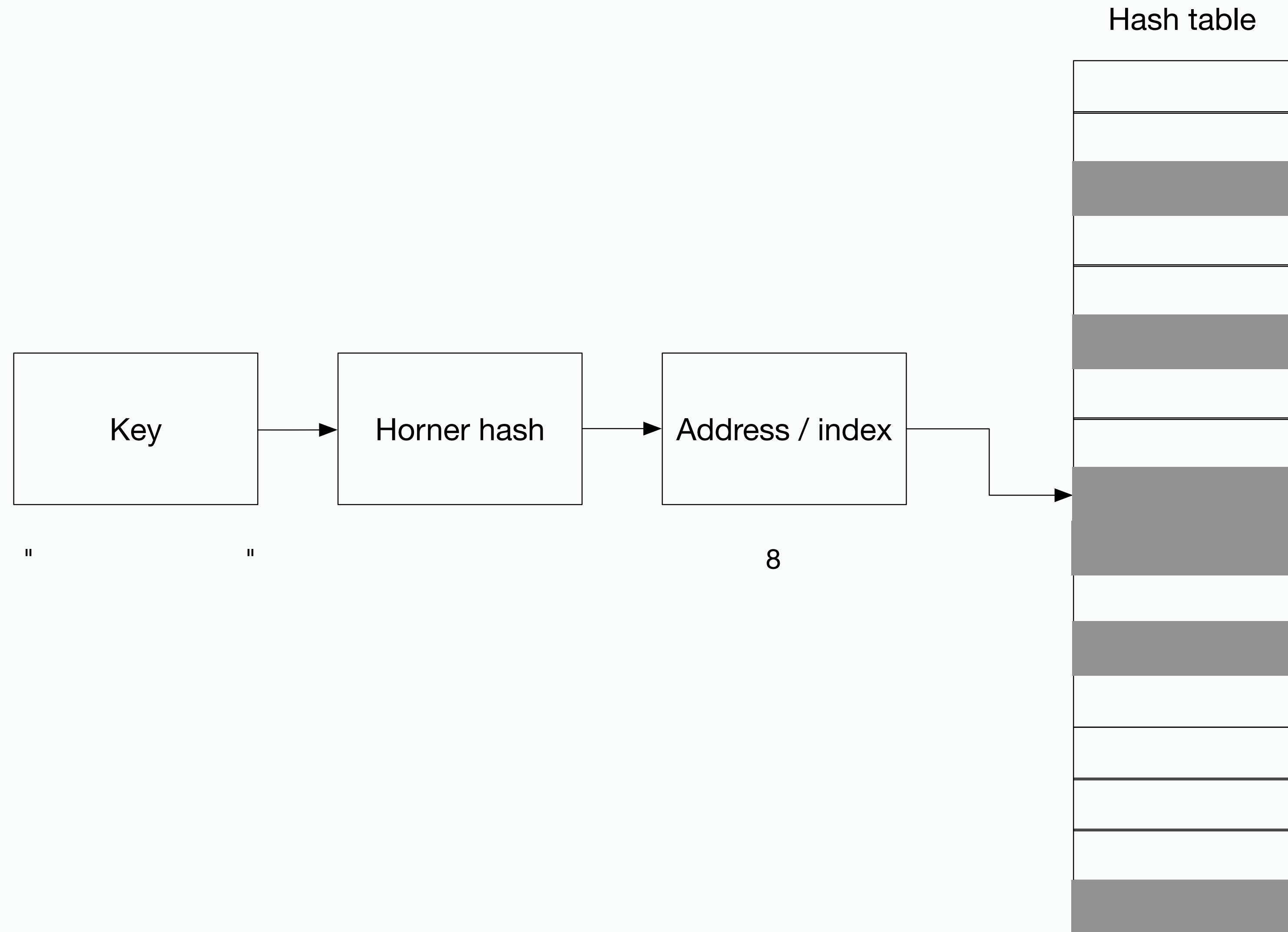
"

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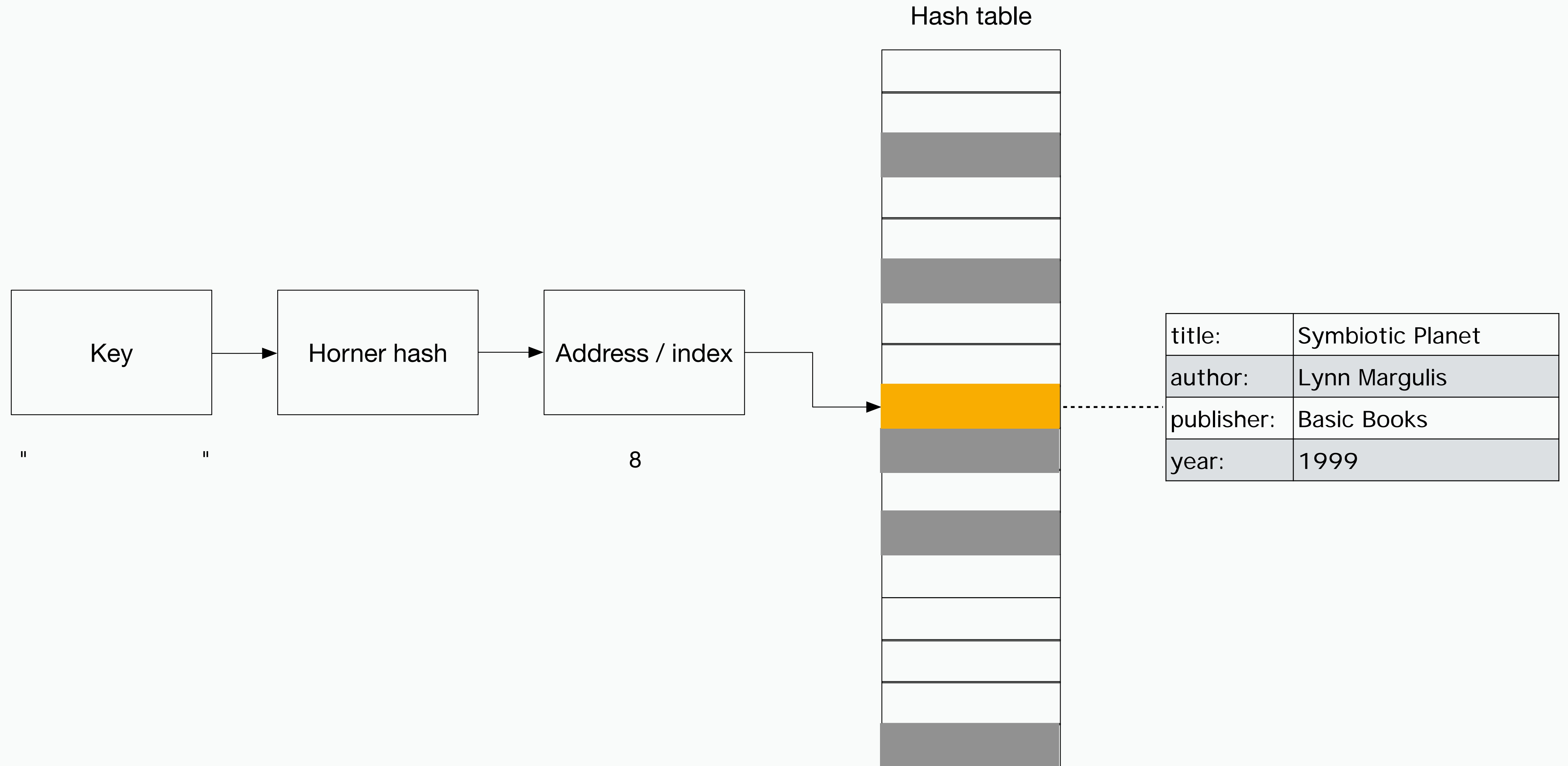
Finding



Finding

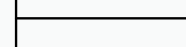
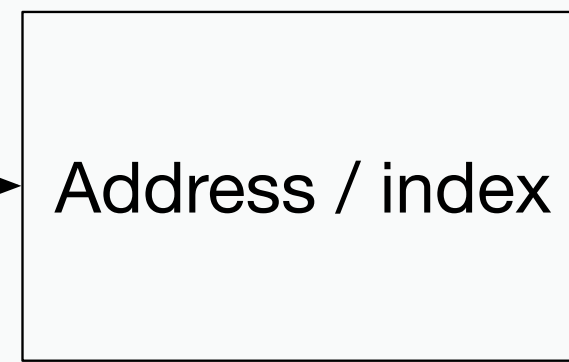
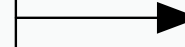
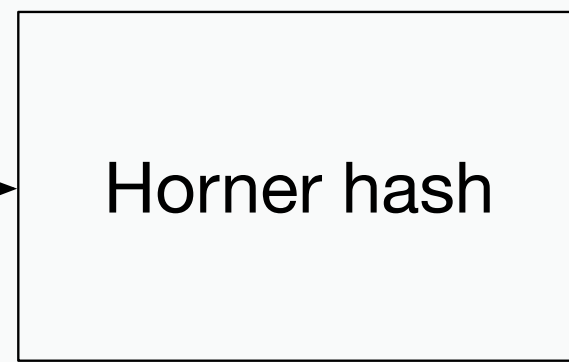
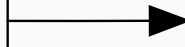
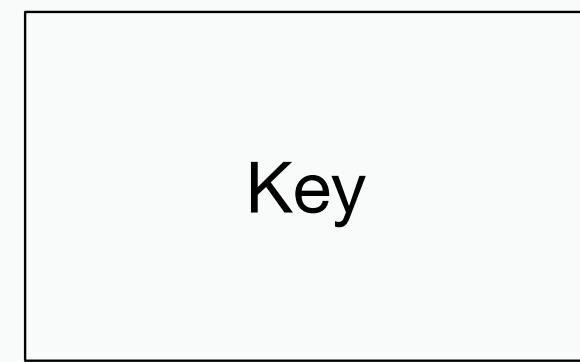
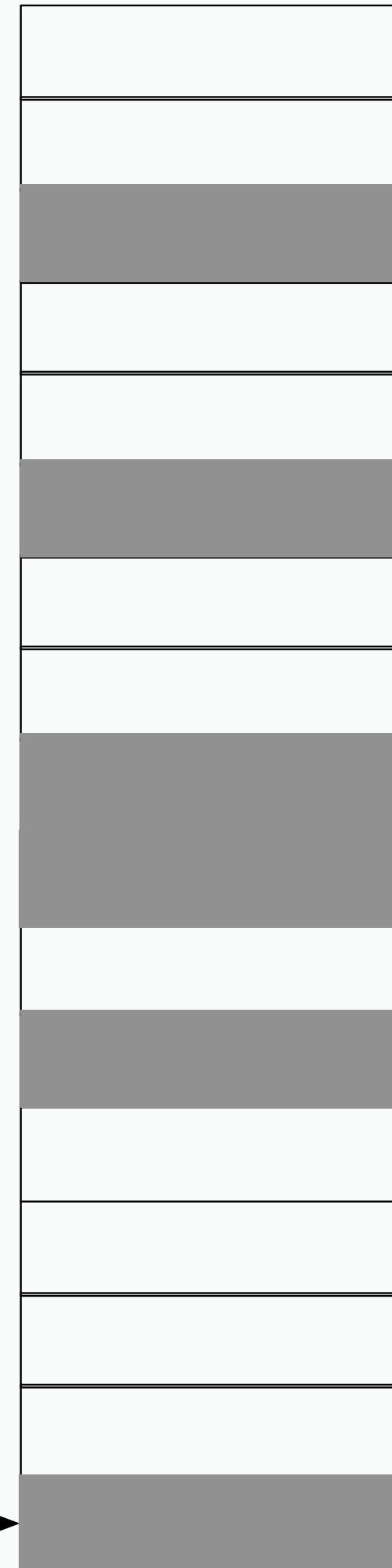


Finding



Finding

Hash table



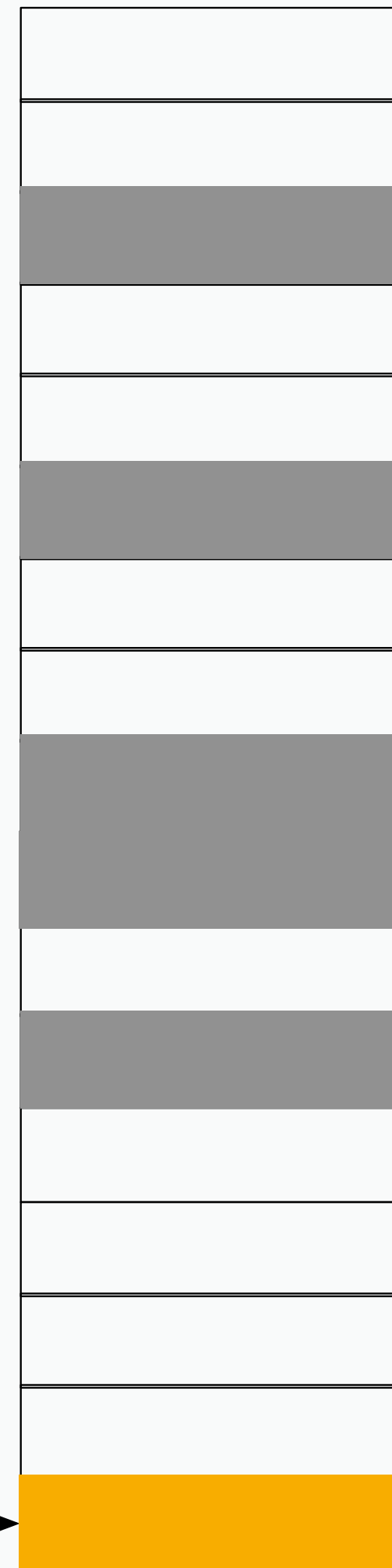
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Finding

Hash table

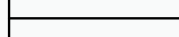
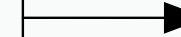
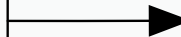


title:	You Are Not A Gadget
author:	Jaron Lanier
publisher:	Basic Books
year:	1999

Key

Horner hash

Address / index



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Finding - what's the complexity?

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Finding - what's the complexity?

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$O(1)$

Deleting - what's the complexity?

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What have we left out?

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ff 'hash collisions'
?' collisions.'
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ff -- "collision
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resolution policies,"
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Summary

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Some questions

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