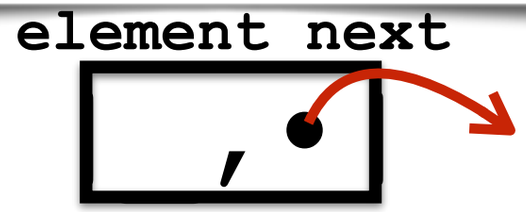
Winter 2016
COMP-250: Introduction to Computer Science

Lecture 6, January 28, 2016

Java Generics

```
class  SNode<E>{
    E                element
    SNode<E>           next
       :
}

class  SLinkedList<E>{
    SNode<E>           head;
    SNode<E>           tail;
    int                size;
       :
}
```



Java Generics

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class  SNode<E>{
    E                element
    SNode<E>           next
       :
}

class  SLinkedList<E>{
    SNode<E>           head;
    SNode<E>           tail;
    int                size;
       :
}
```

```
SLinkedList<Shape>    shapelist = new SLinkedList<Shape>();
SLinkedList<Student>  studentlist = new SLinkedList<Student>();
```

Java Generics

```
class  DNode<E>{
   E                element;
   DNode<E>            next;
   DNode<E>            prev;
      :
}

class  DLinkedList<E>{
   DNode<E>            head;
   DNode<E>            tail;
   int                 size;
      :
}
```

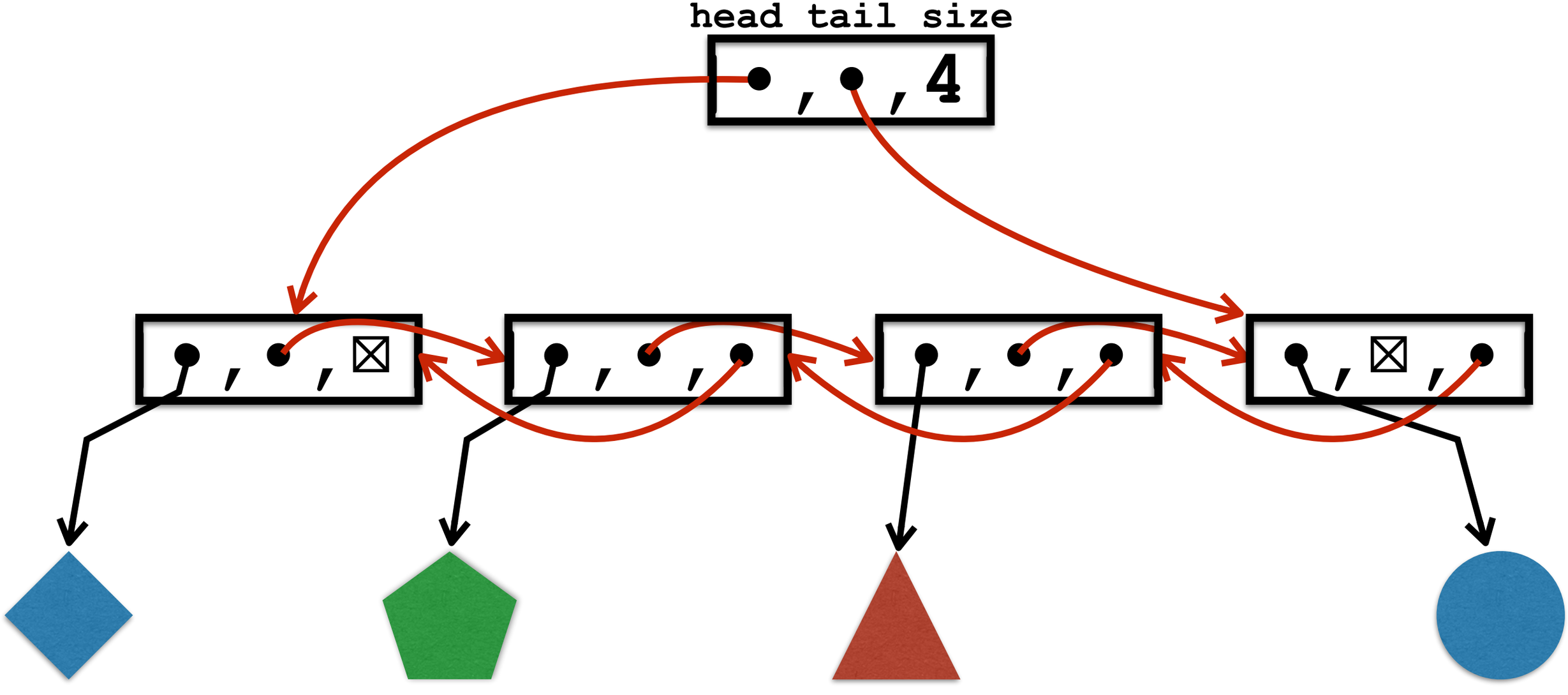
```
DLinkedList<Shape>    shapelist = new DLinkedList<Shape>();
DLinkedList<Student>  studentlist = new DLinkedList<Student>();
```

(Doubly) Linked List

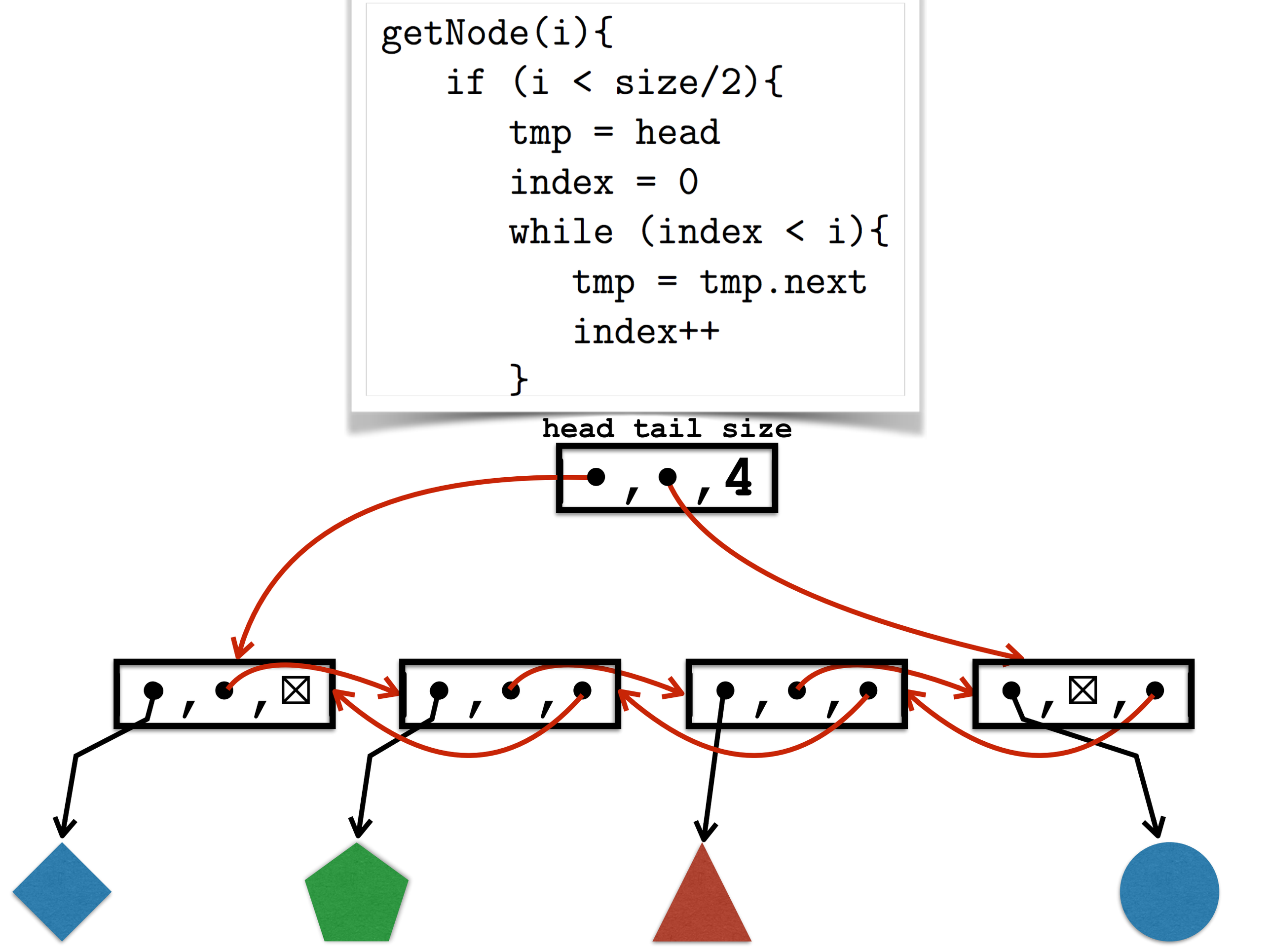
(Doubly) Linked List Node

```
class  DNode<E>{
    E                element;
    DNode<E>           next;
    DNode<E>           prev;
       :
}
```

```
class  DLinkedList<E>{
    DNode<E>          head;
    DNode<E>          tail;
    int               size;
       :
}
```



```
getNode(i){
    if (i < size/2){
        tmp = head
        index = 0
        while (index < i){
            tmp = tmp.next
            index++
        }
```



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getNode(i){
    if (i < size/2){
        tmp = head
        index = 0
        while (index < i){
            tmp = tmp.next
            index++
        }
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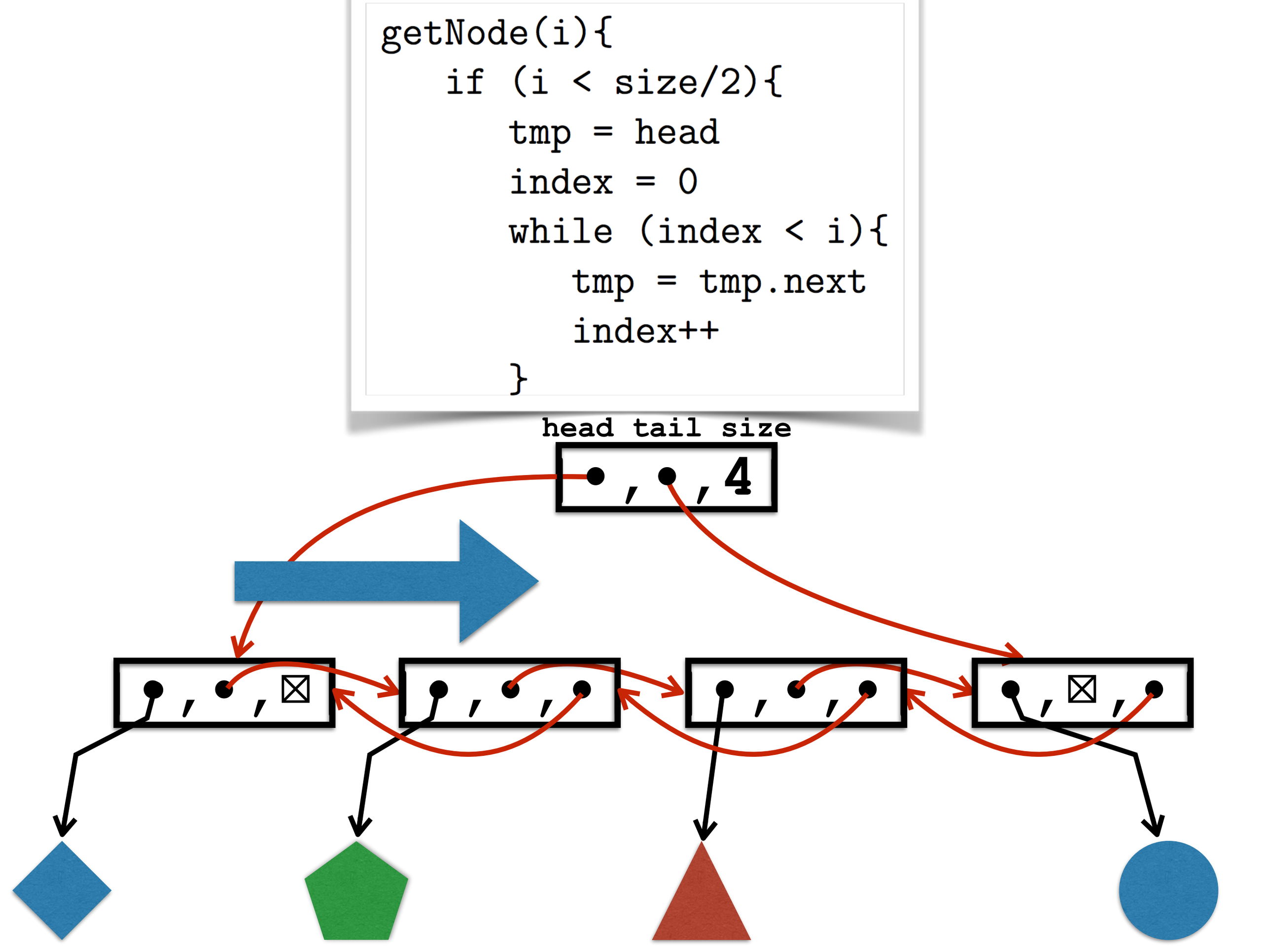
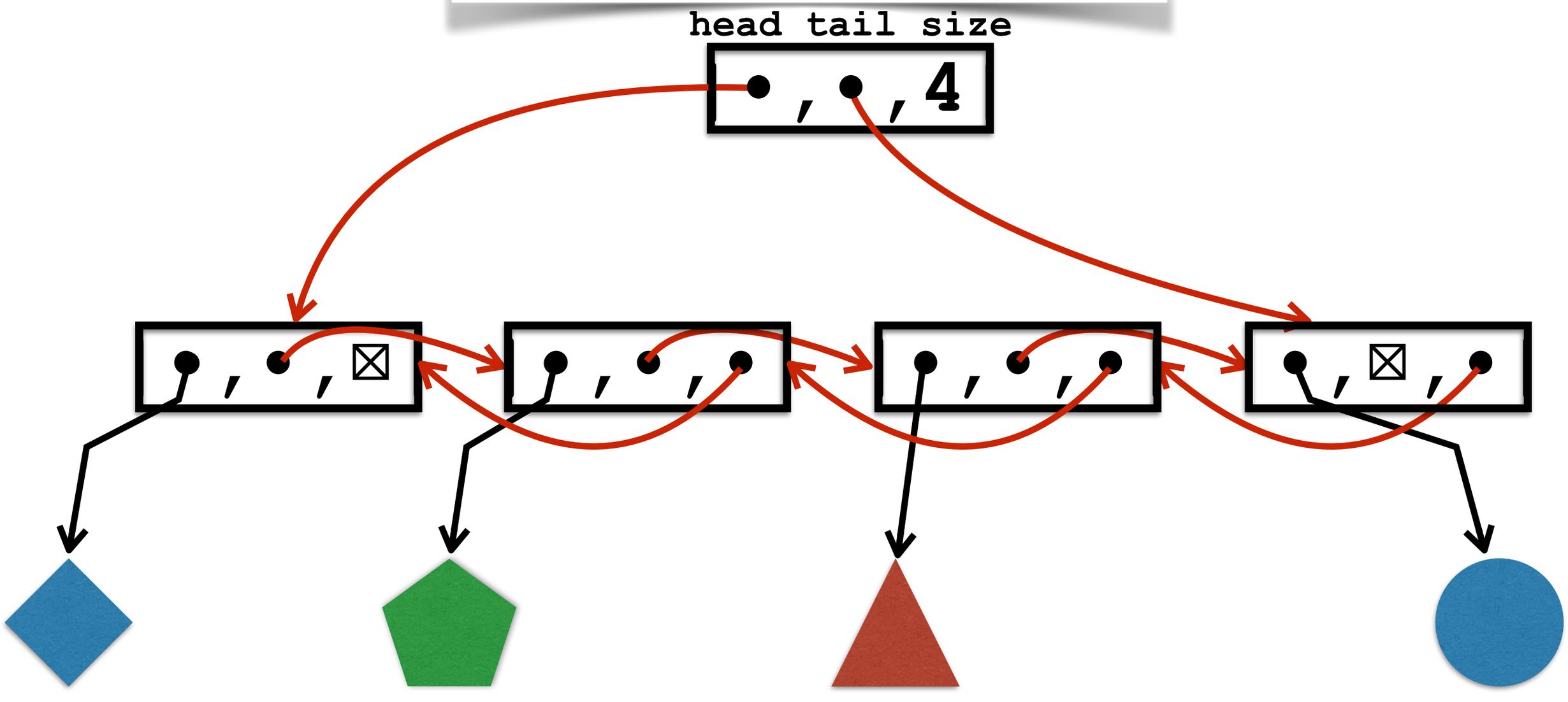


```
    else{
        tmp = tail
        index = size - 1
        while (index > i){
            tmp = tmp.prev
            index--
        }
    return tmp
```



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        tmp = tail
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            tmp = tmp.prev
            index--
        }
    return tmp
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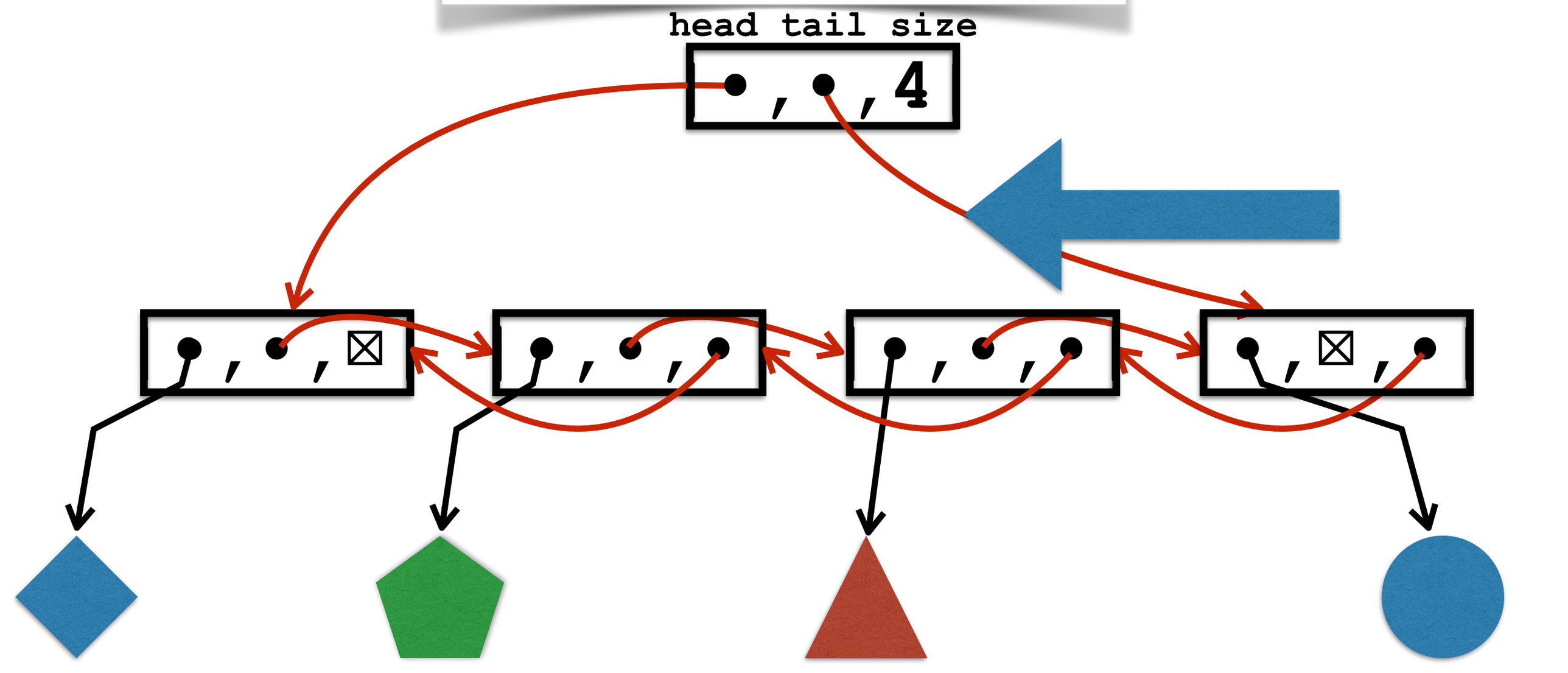
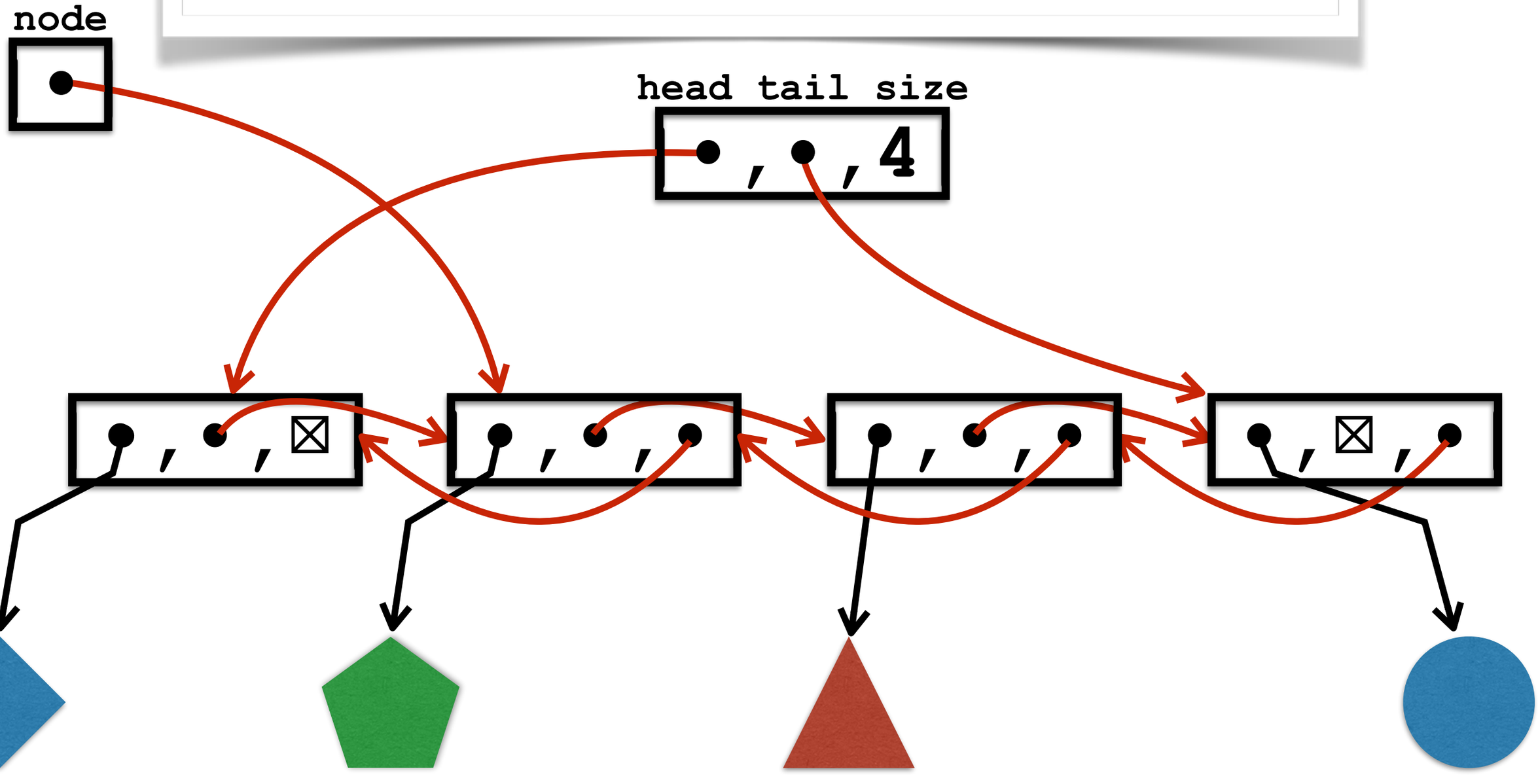


```
remove( node ){
    node.prev.next = node.next;
    node.next.prev = node.prev;
    size           = size-1;
}
```



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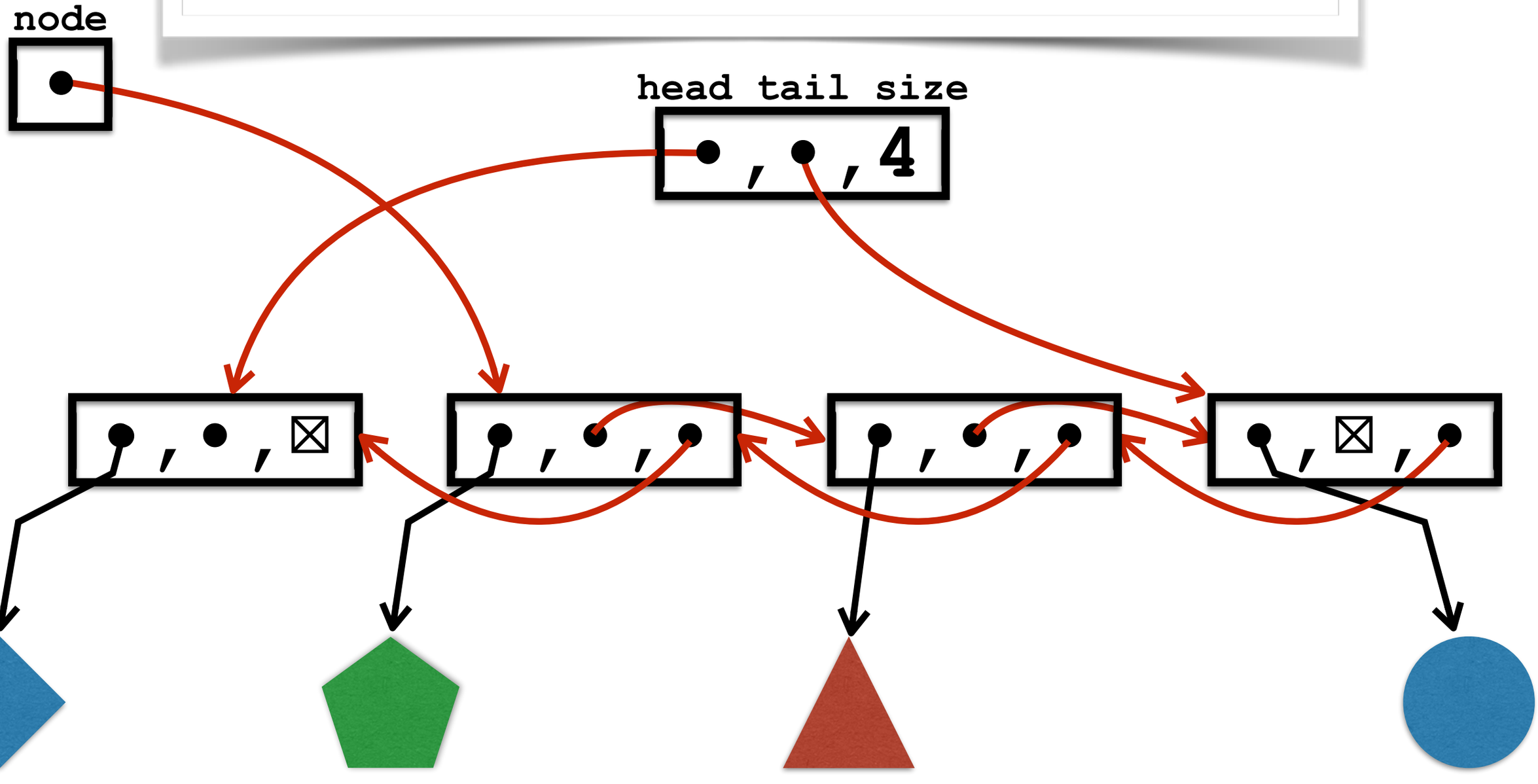

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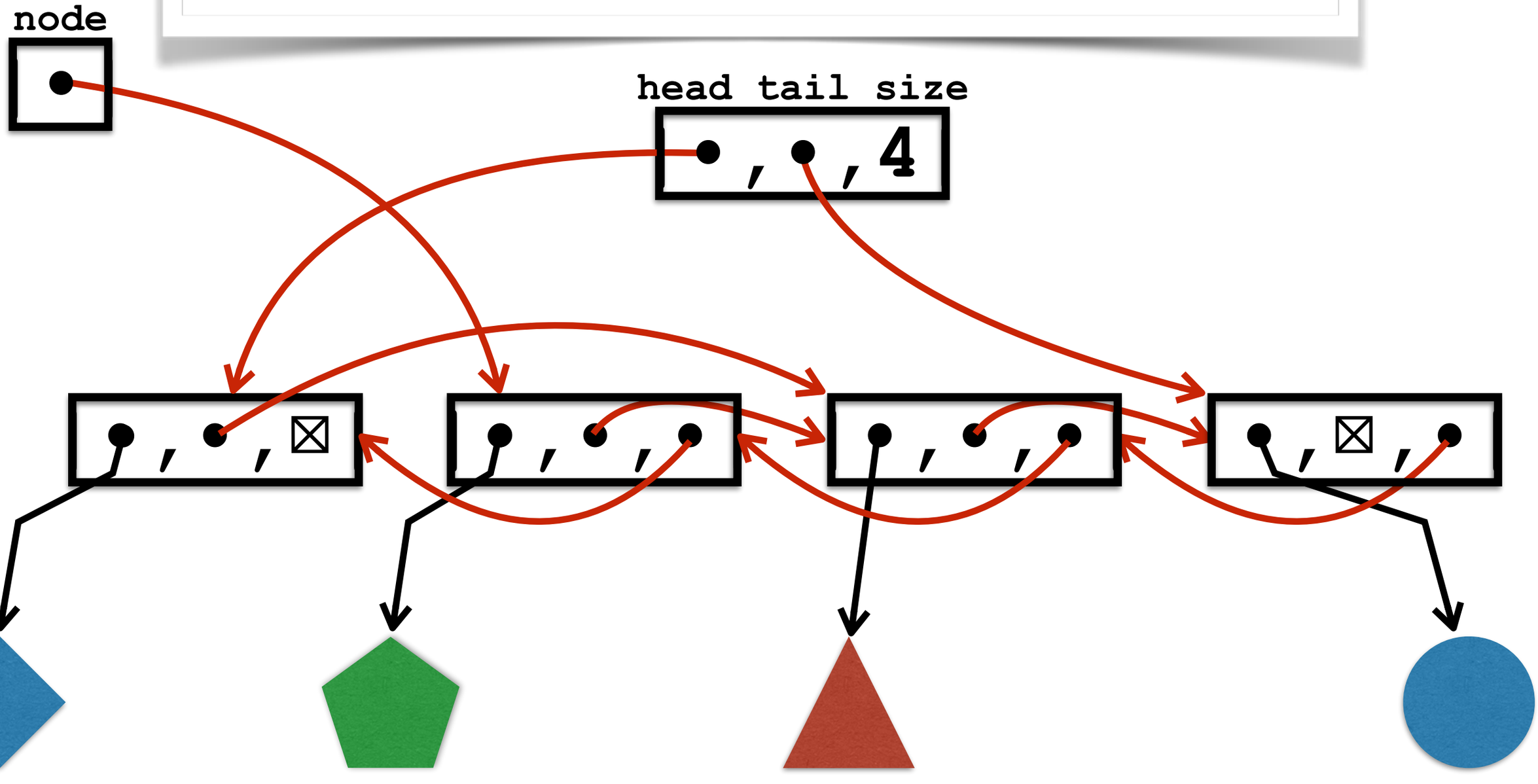

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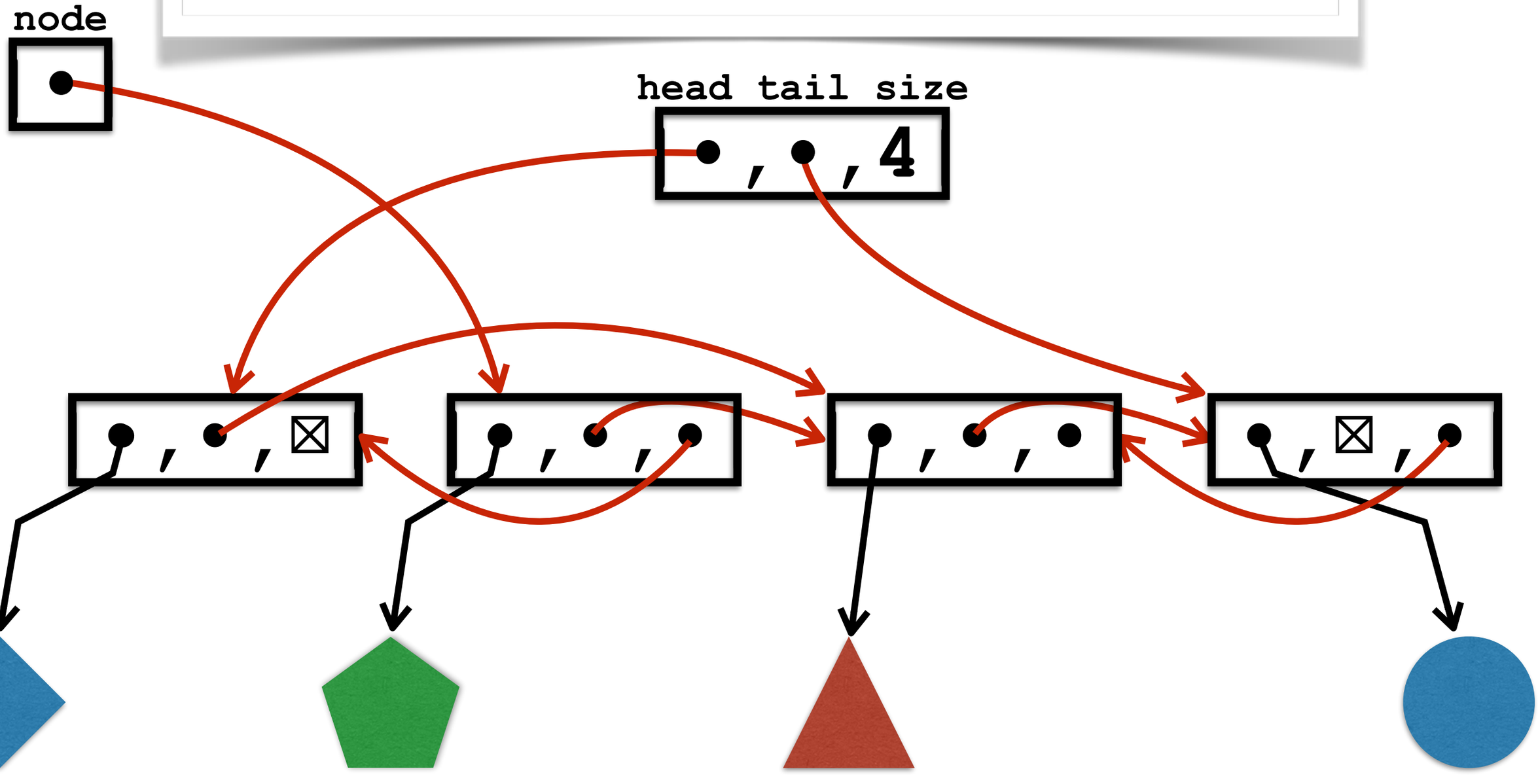

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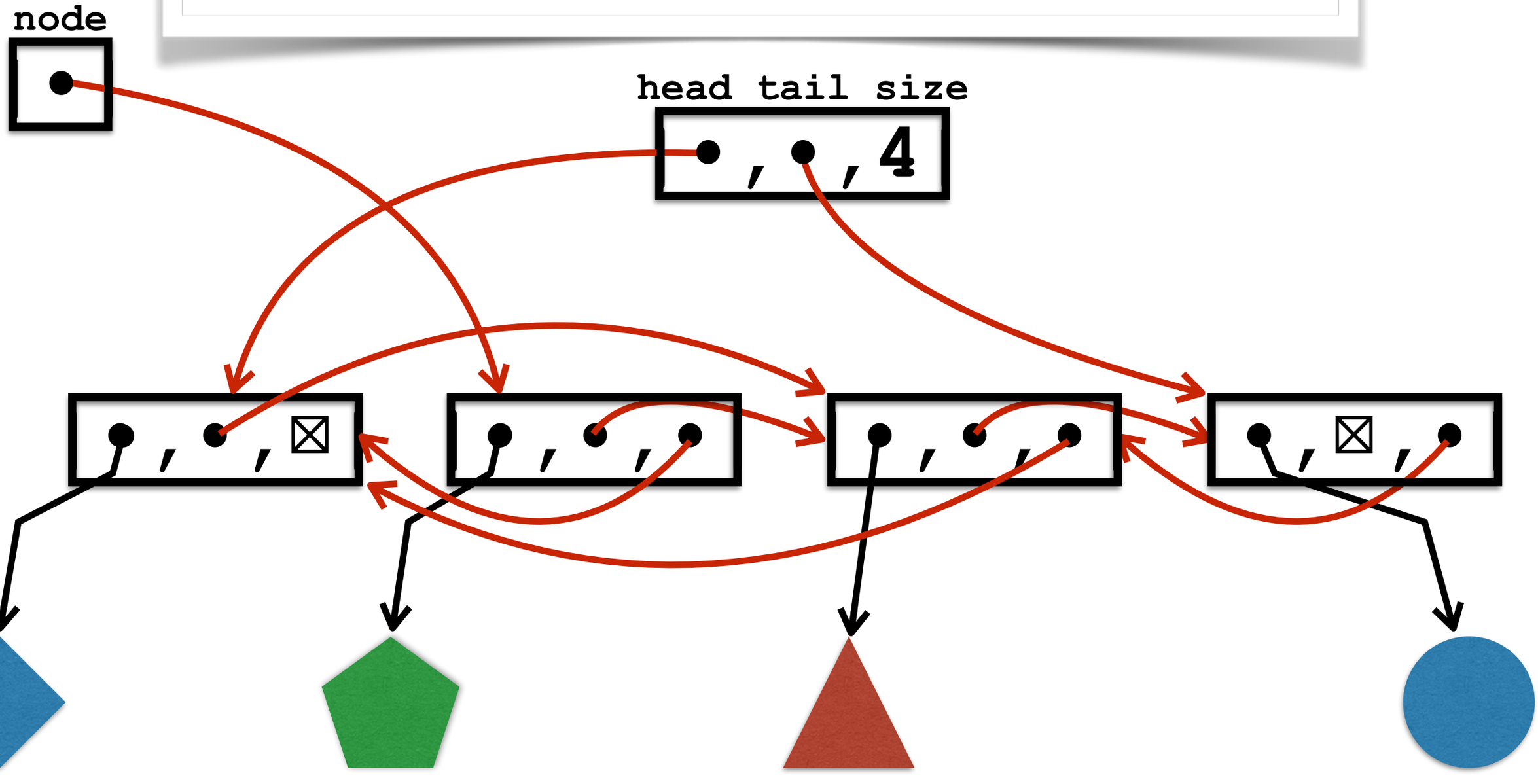

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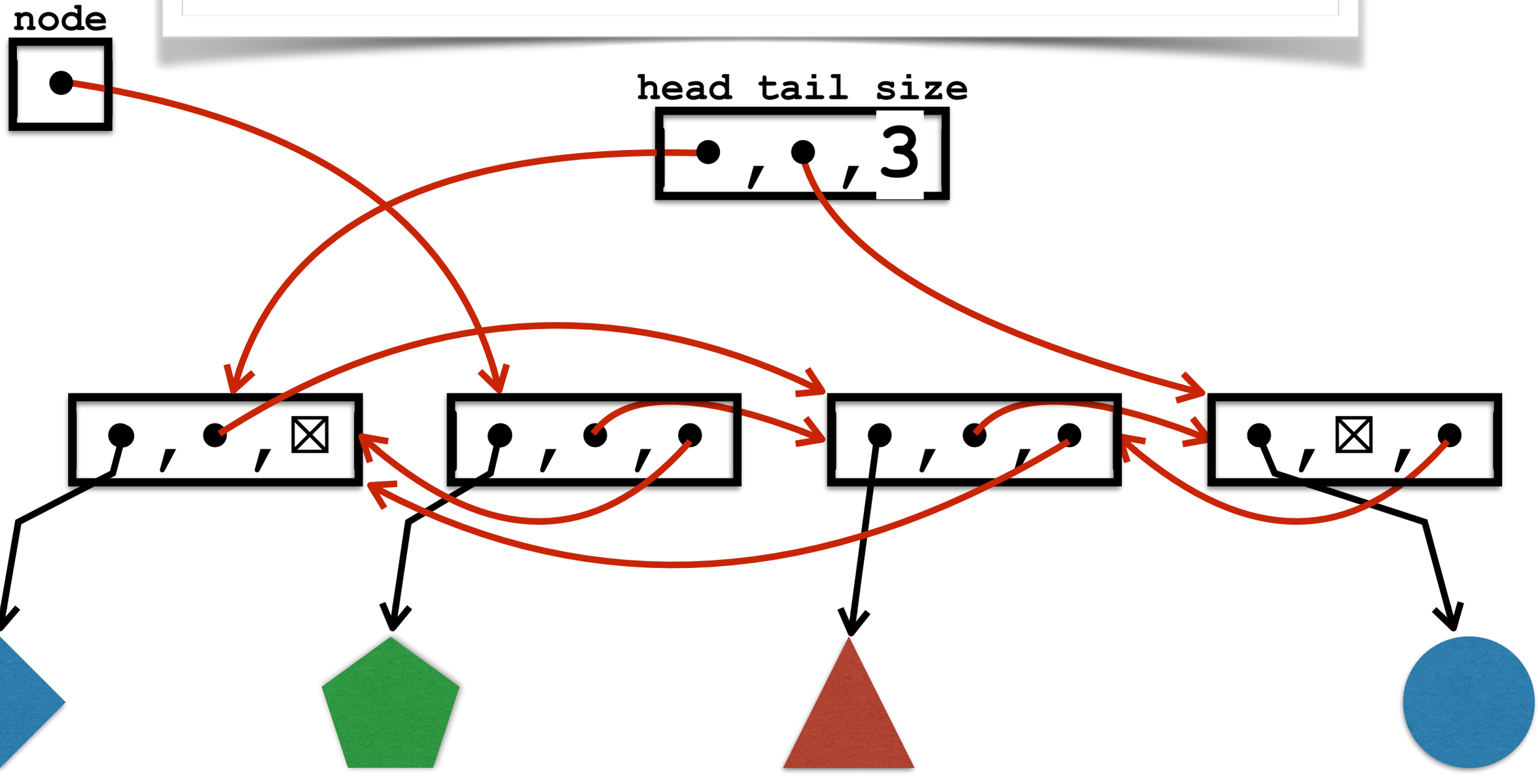

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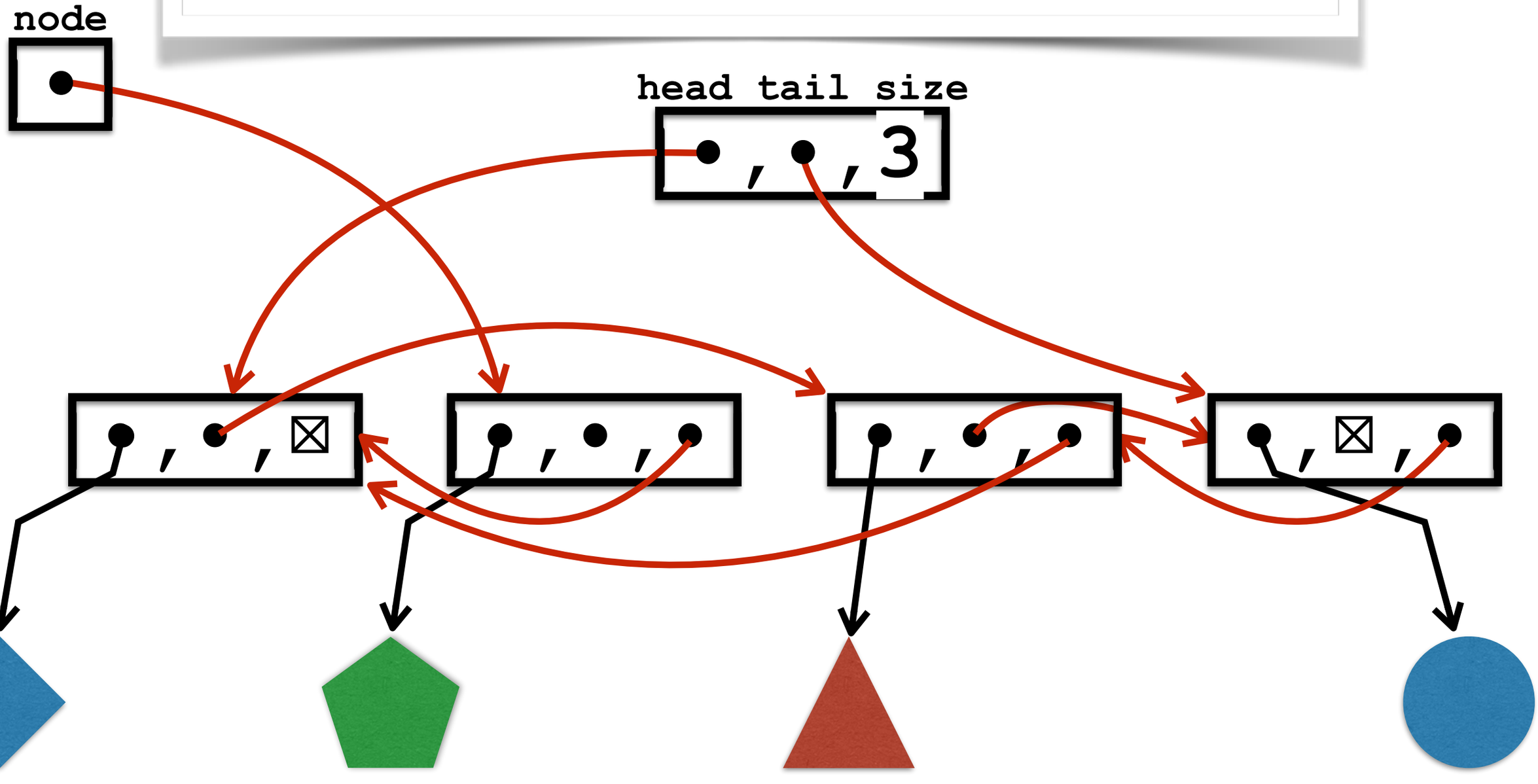

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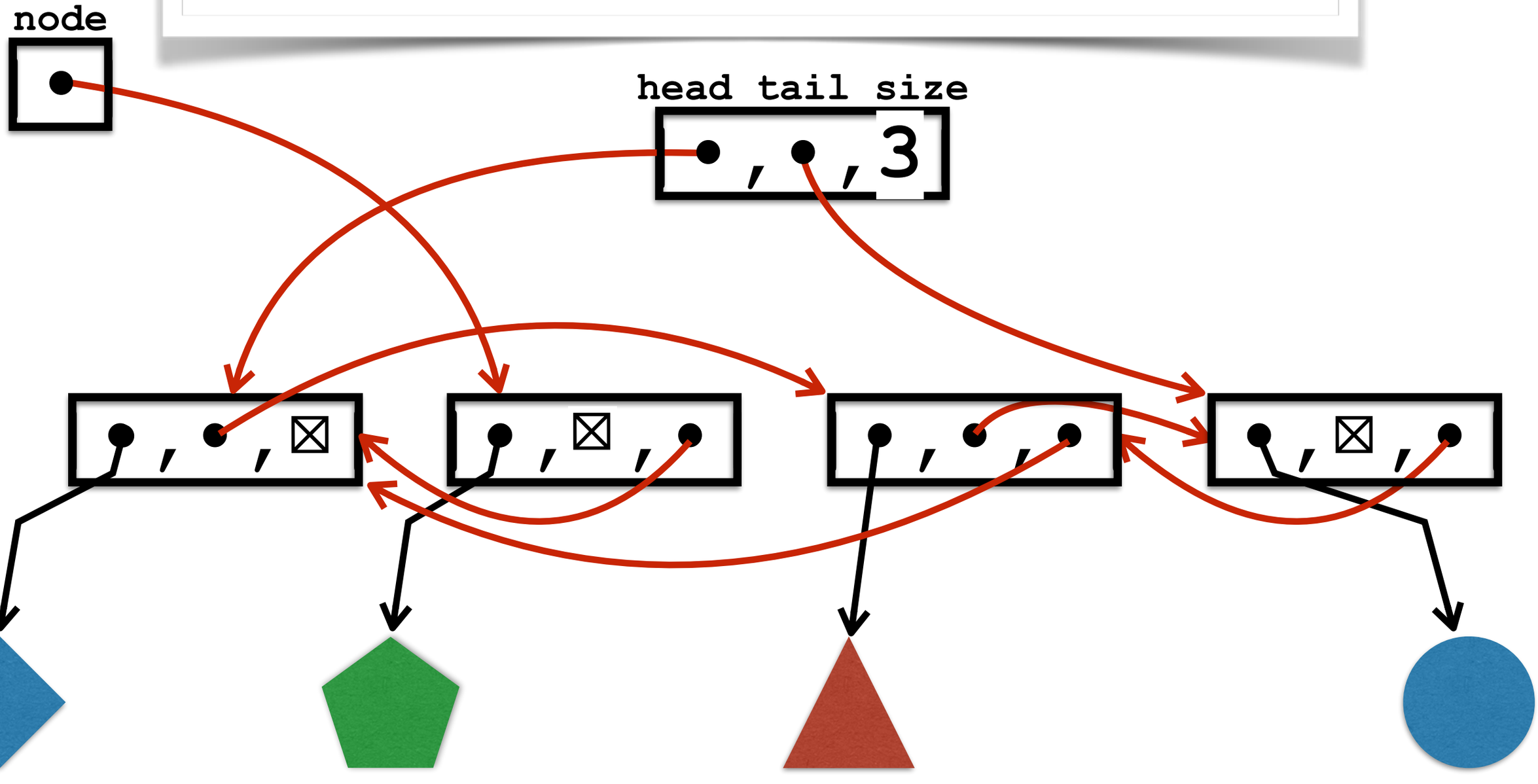

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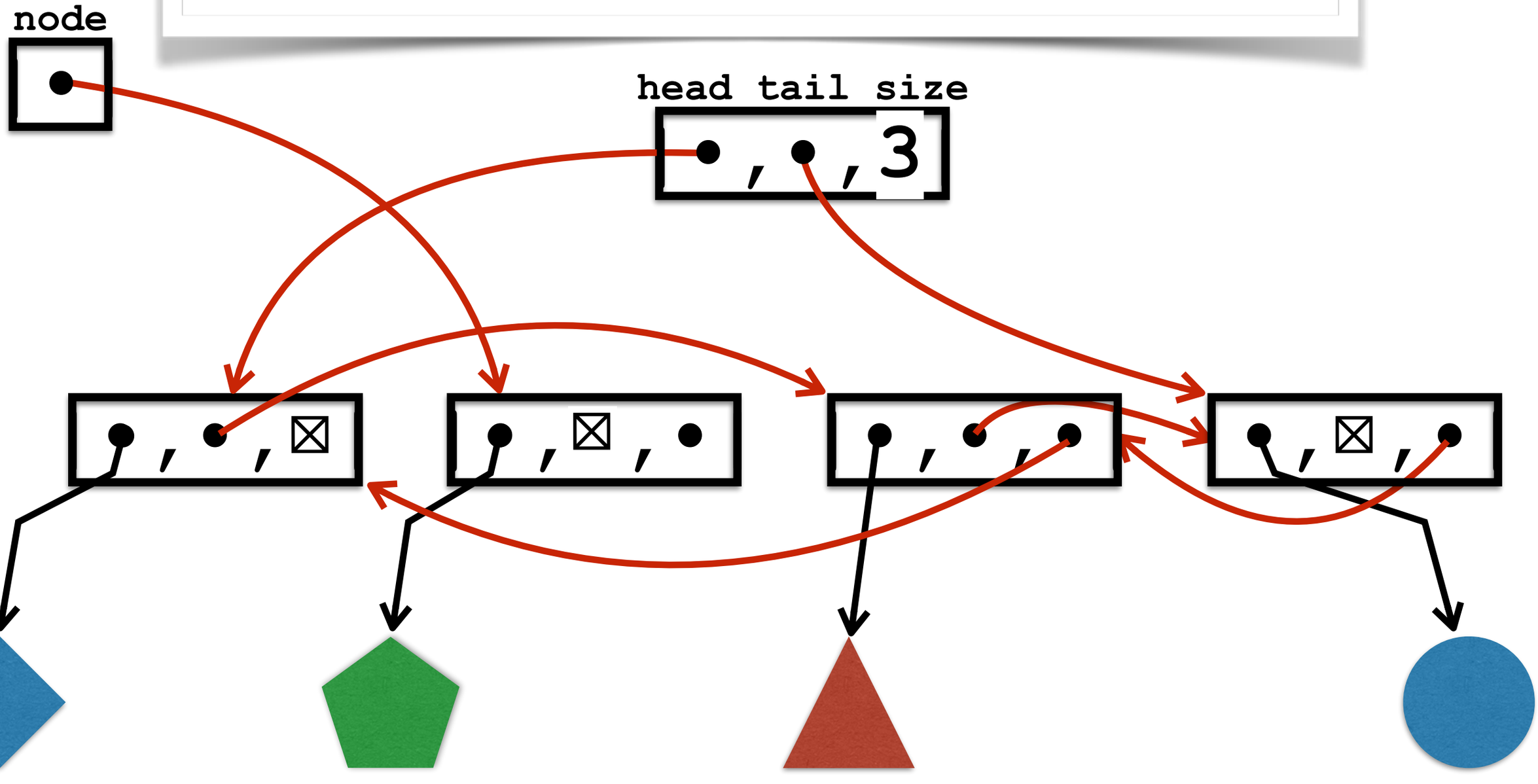

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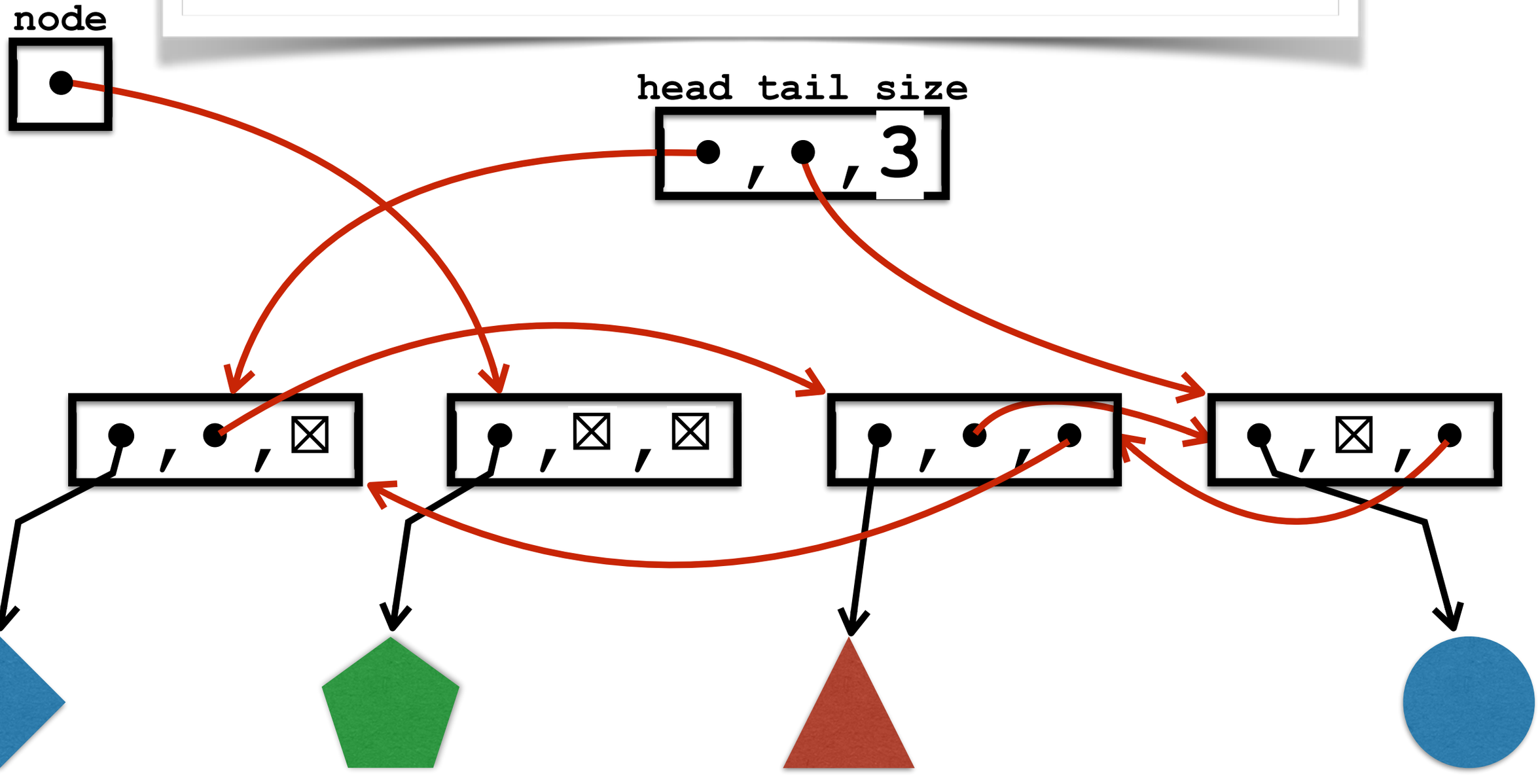

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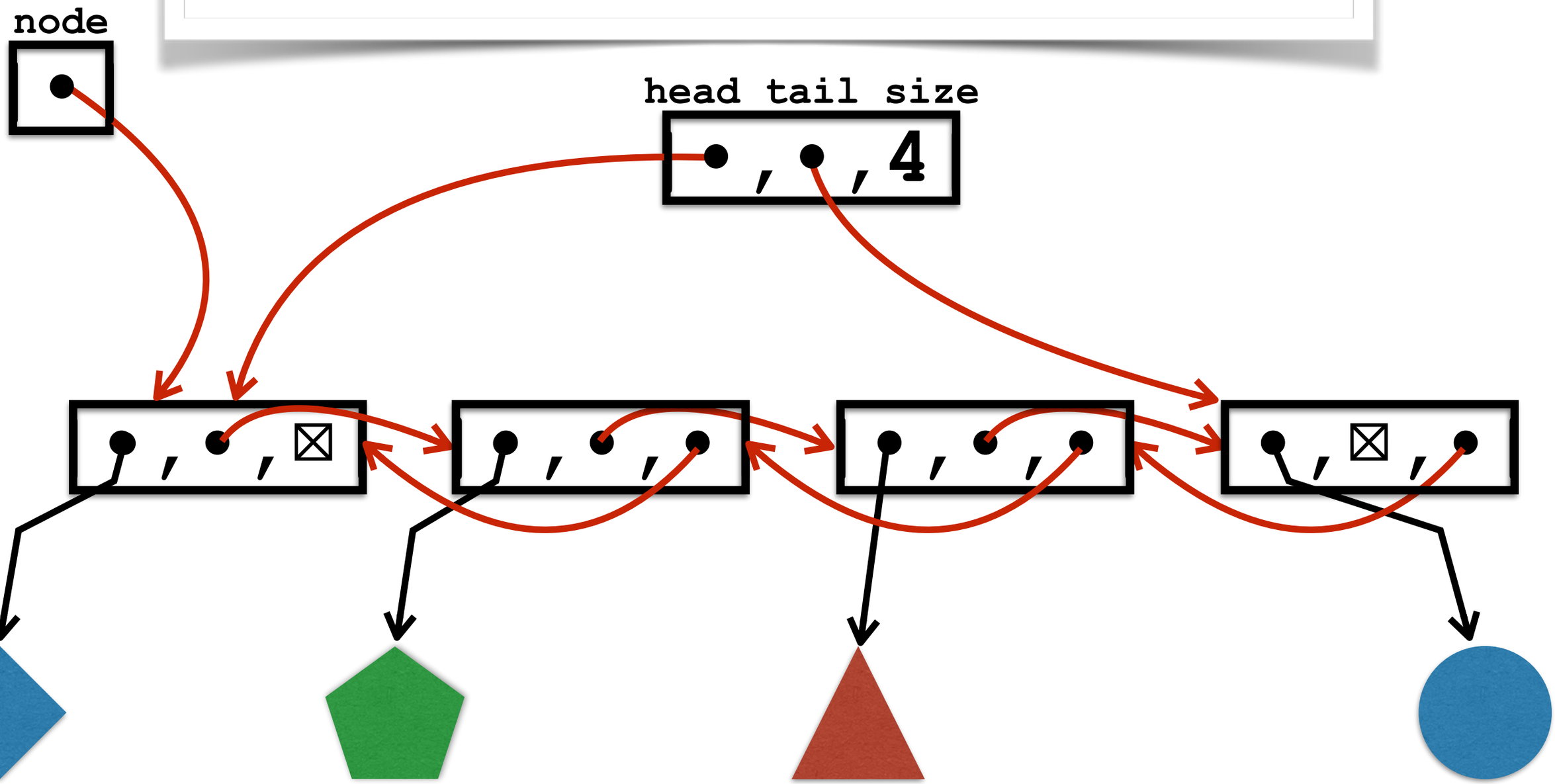

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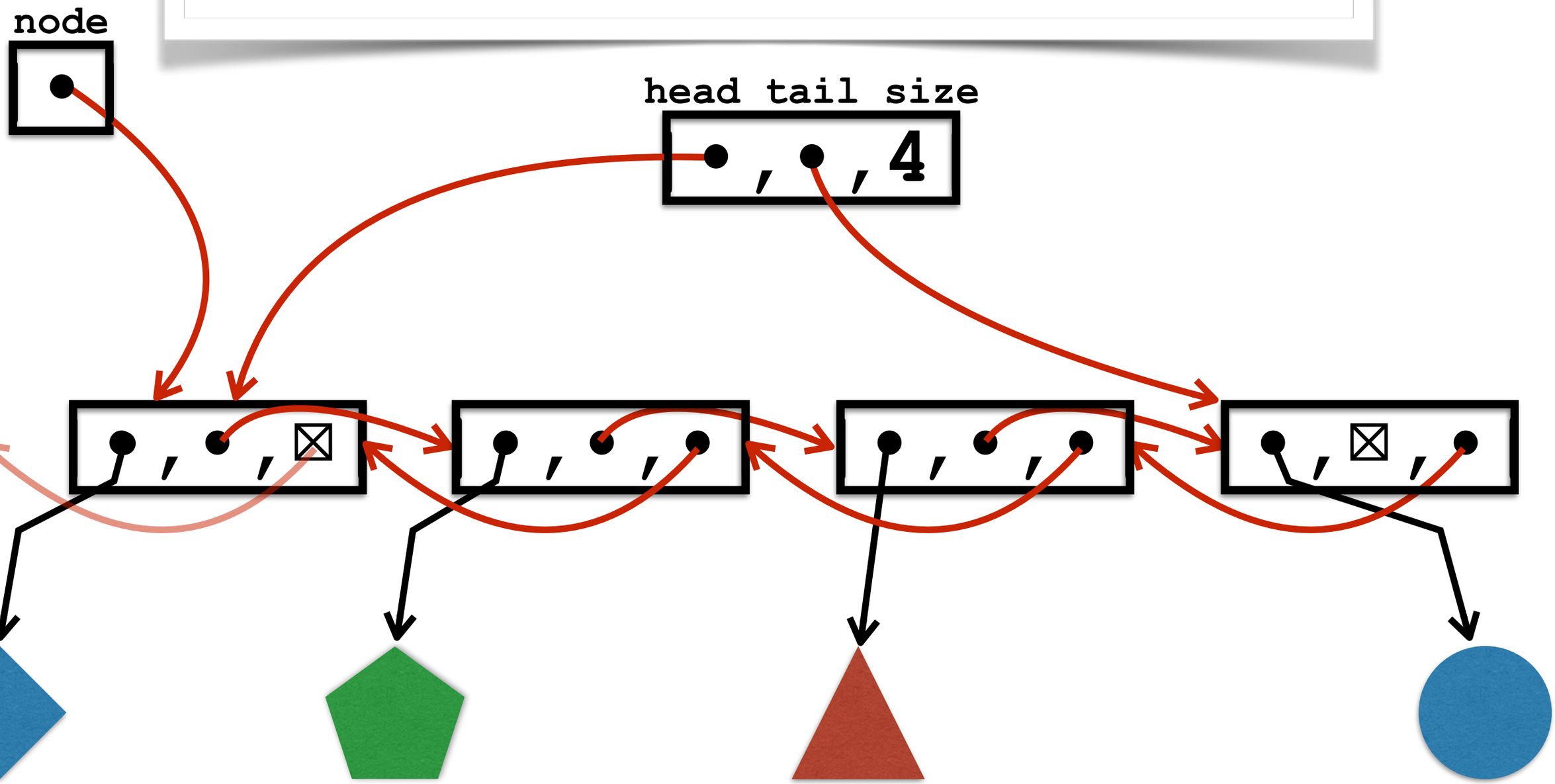
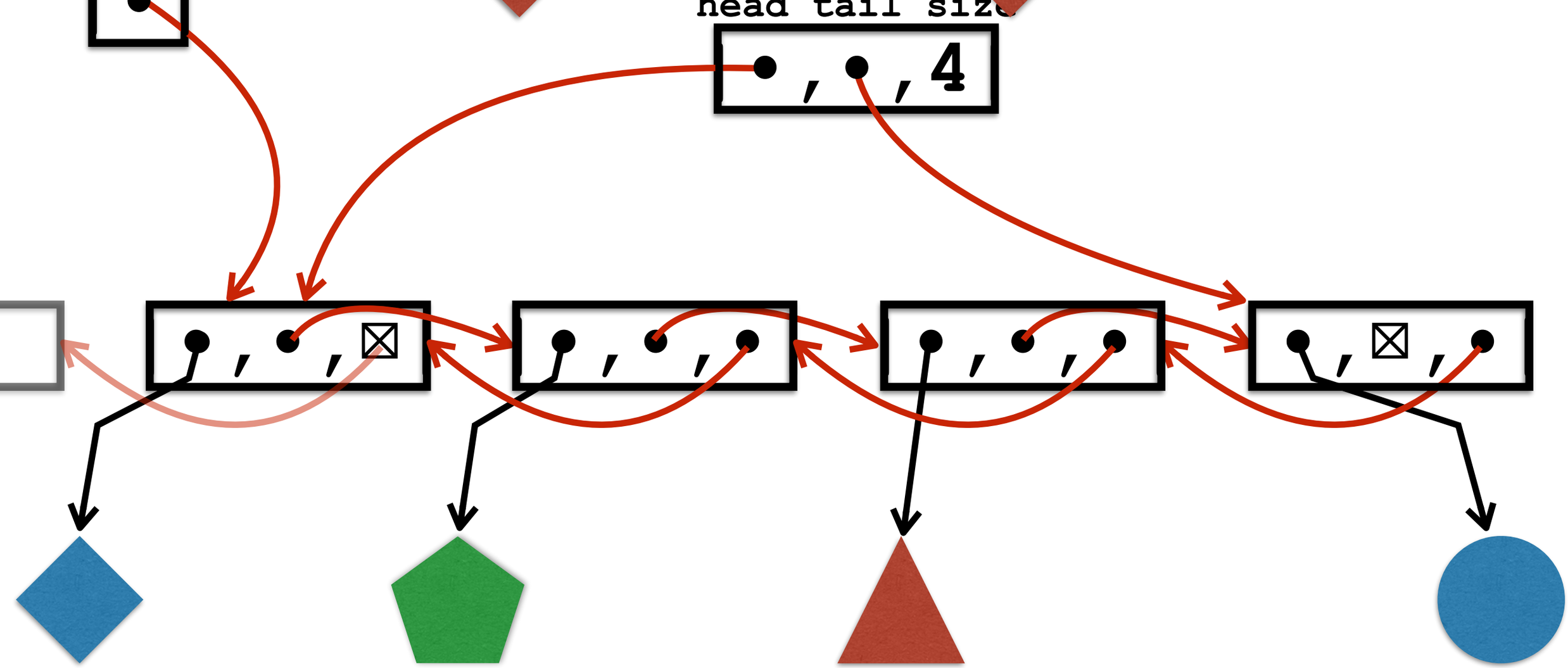


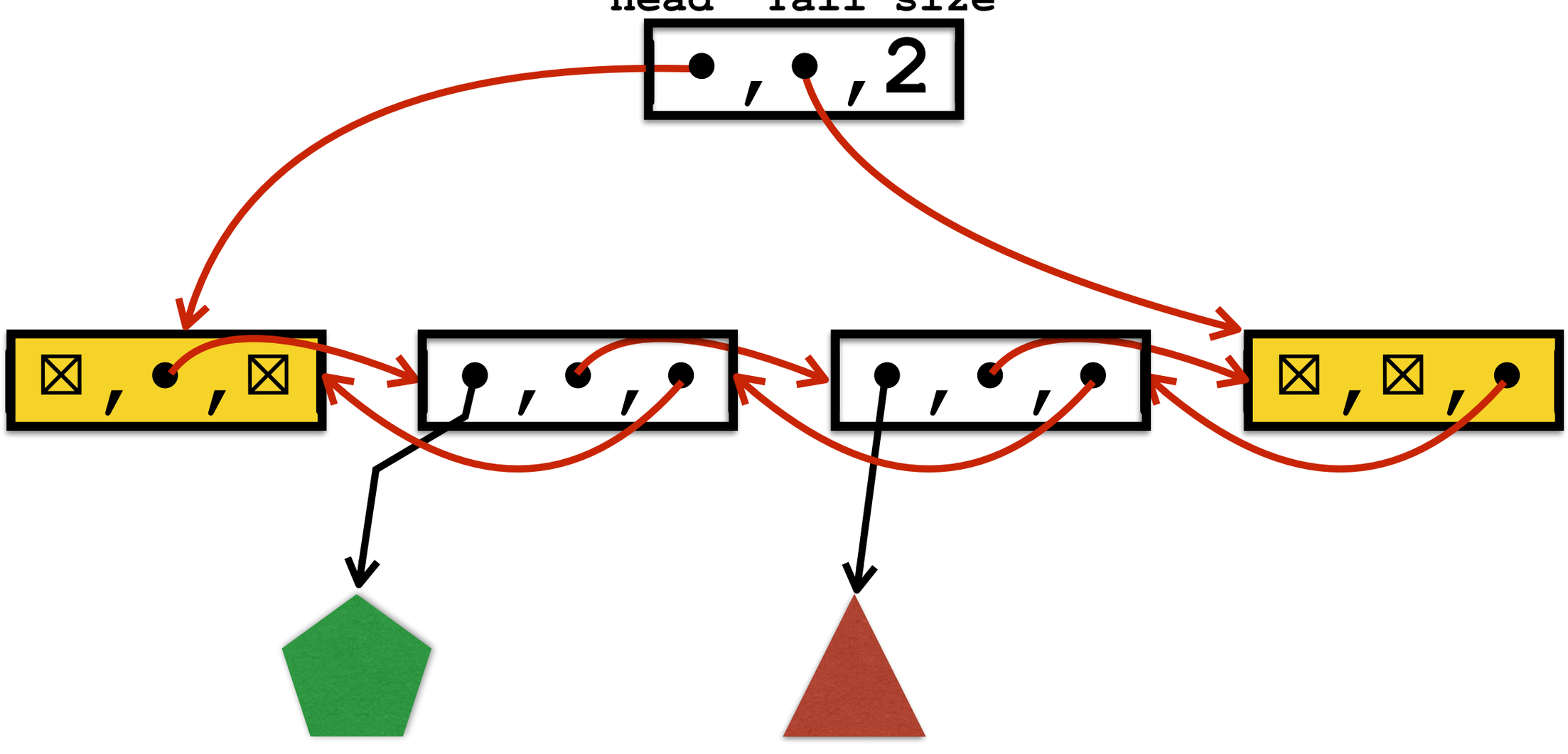
```
remove( ode ){
    node.pr .ne  = node.next;
    node.next. ev = node.prev;
    size          = size-1;
}
```

node

head tail size



```
class  DLinkedList<E>{
   DNode<E>              dummyHead;
   DNode<E>              dummyTail;
   int                   size;
   }
```



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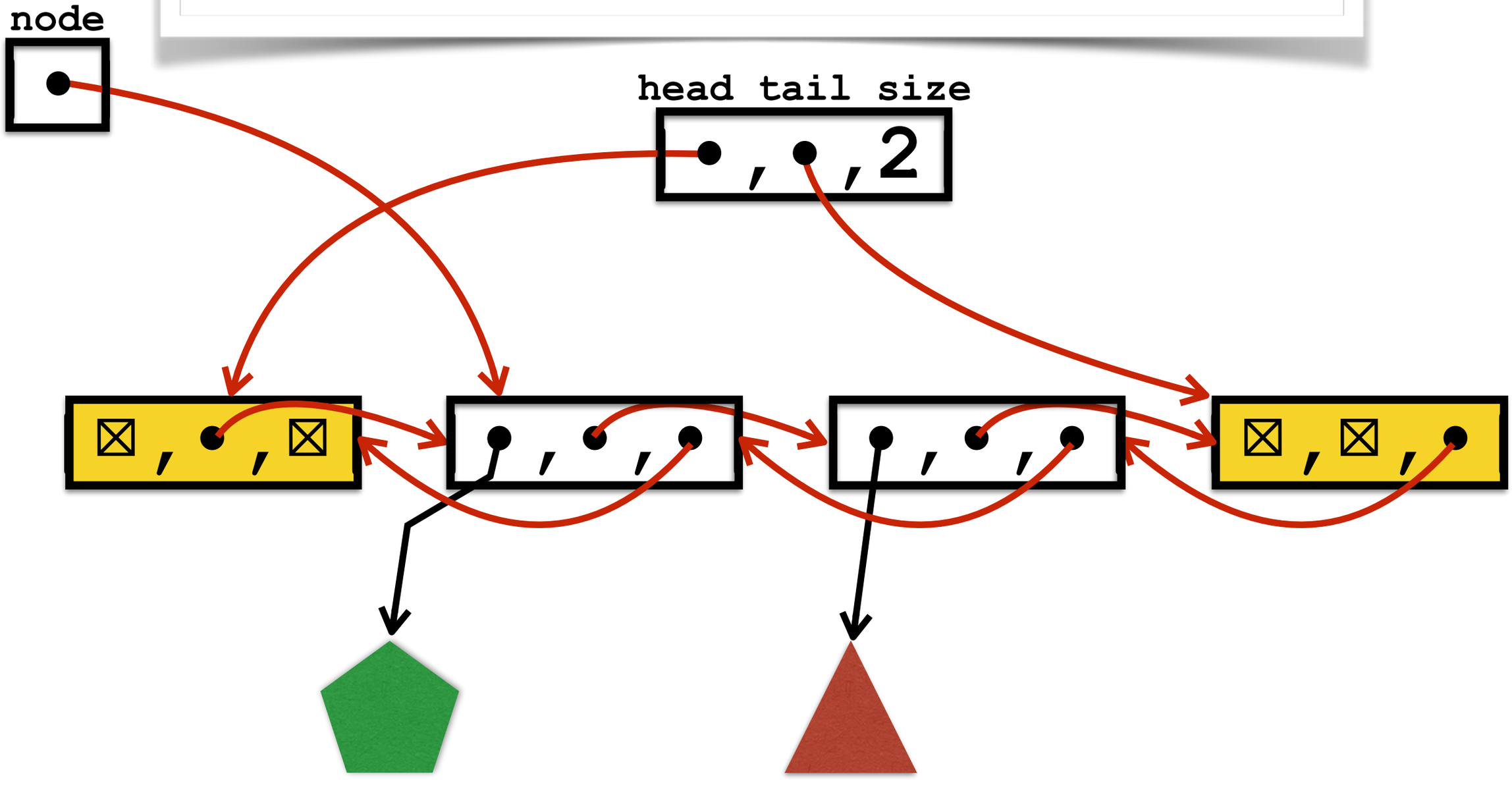

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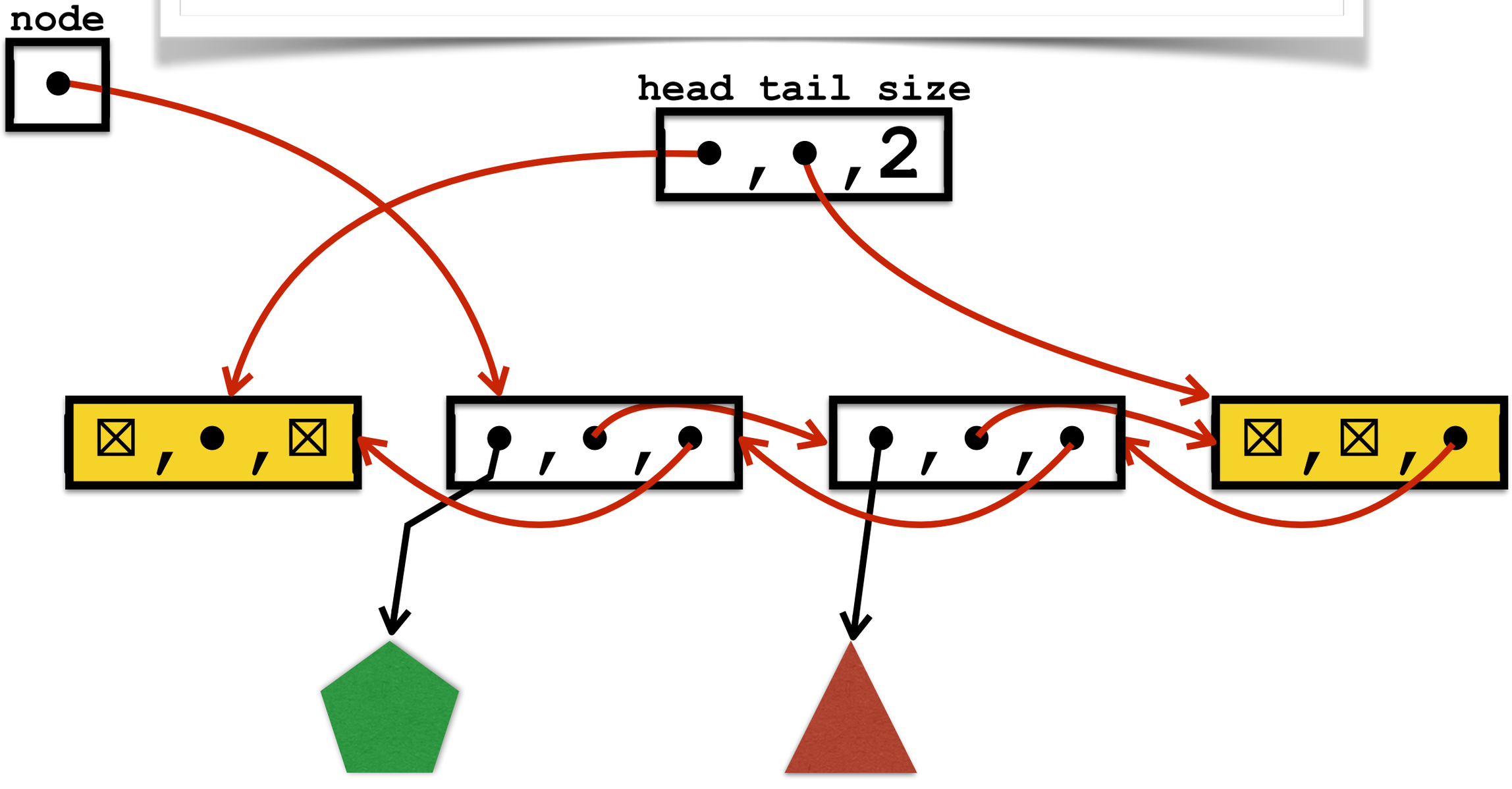

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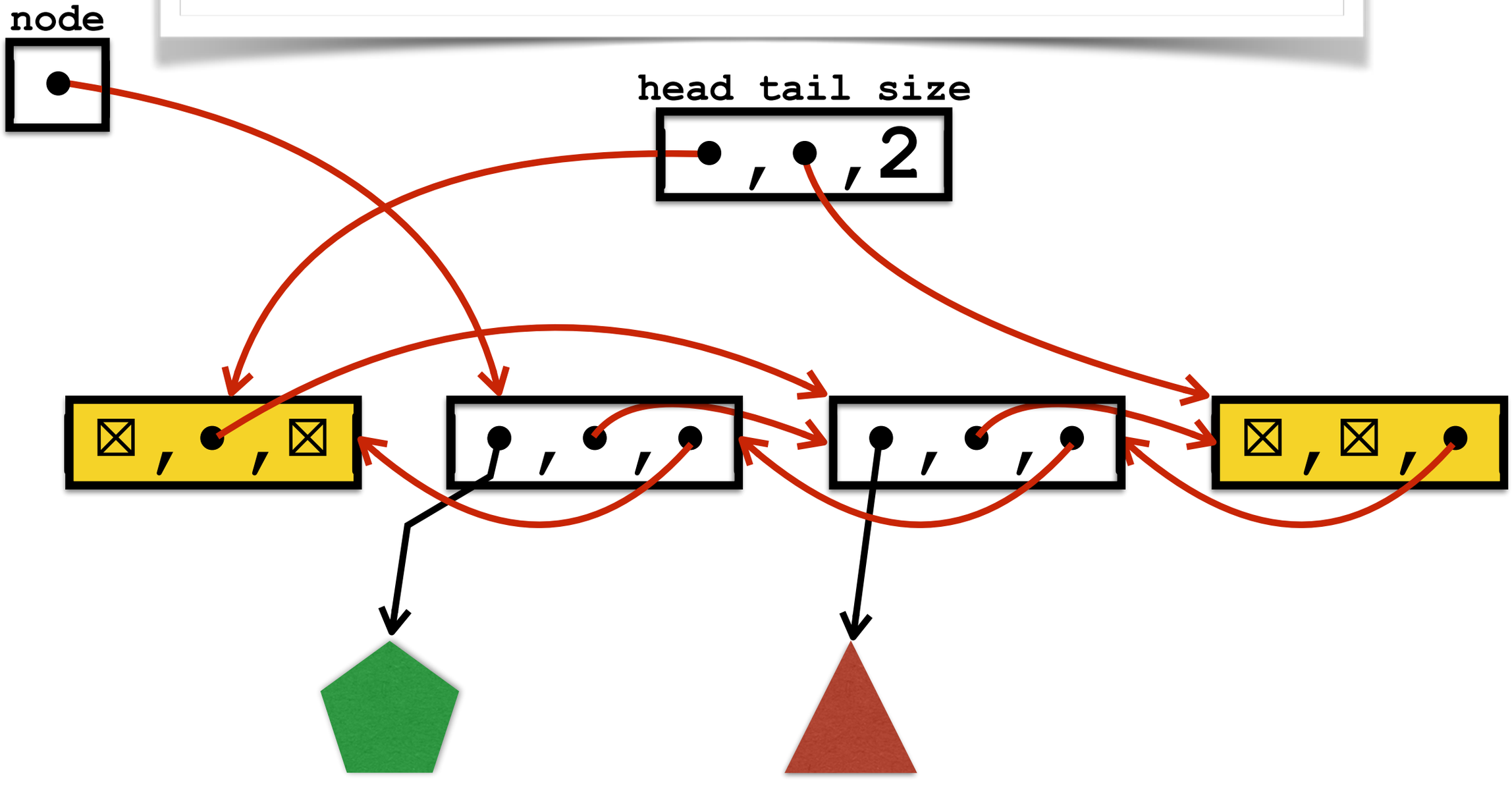

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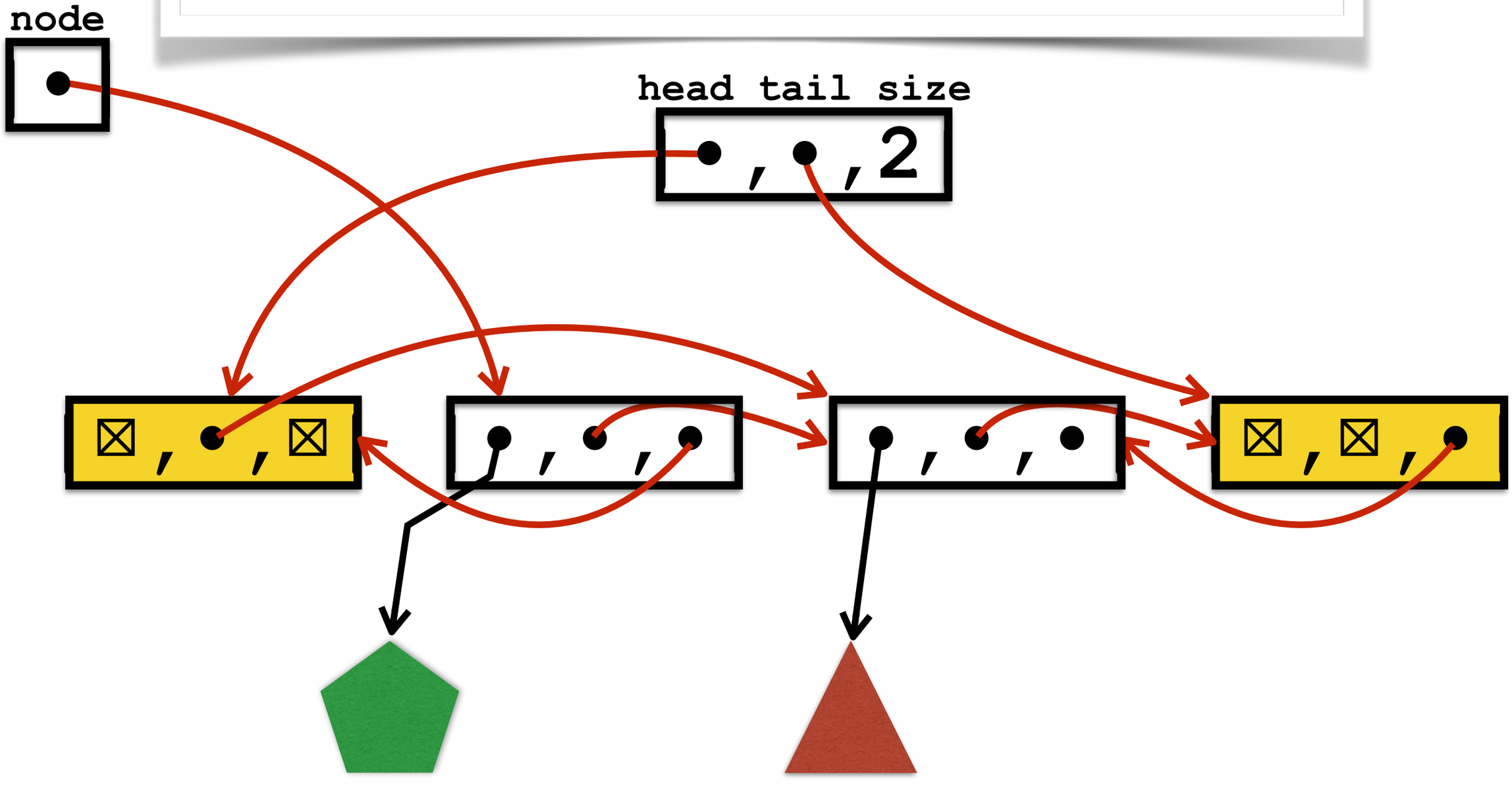

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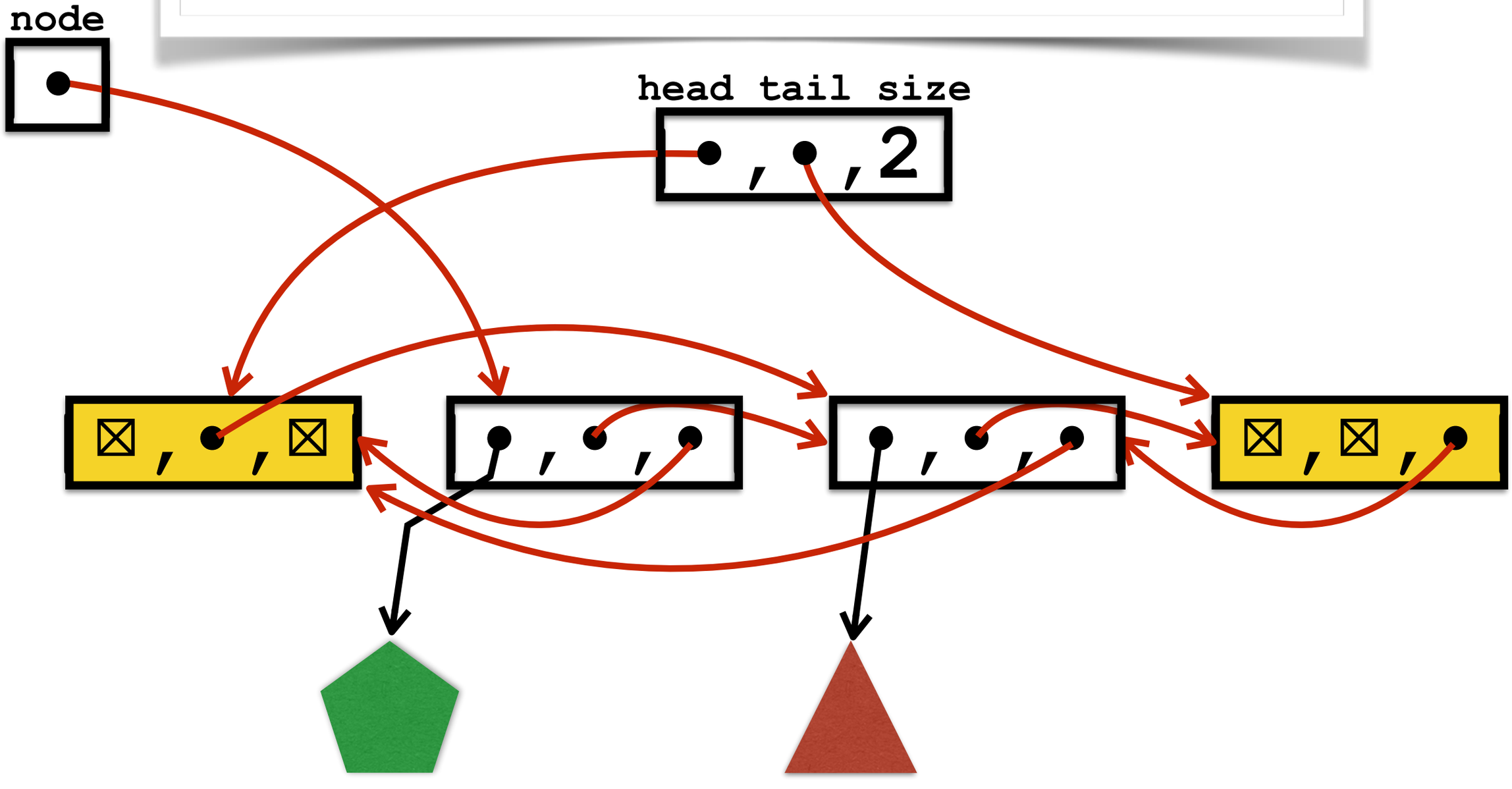

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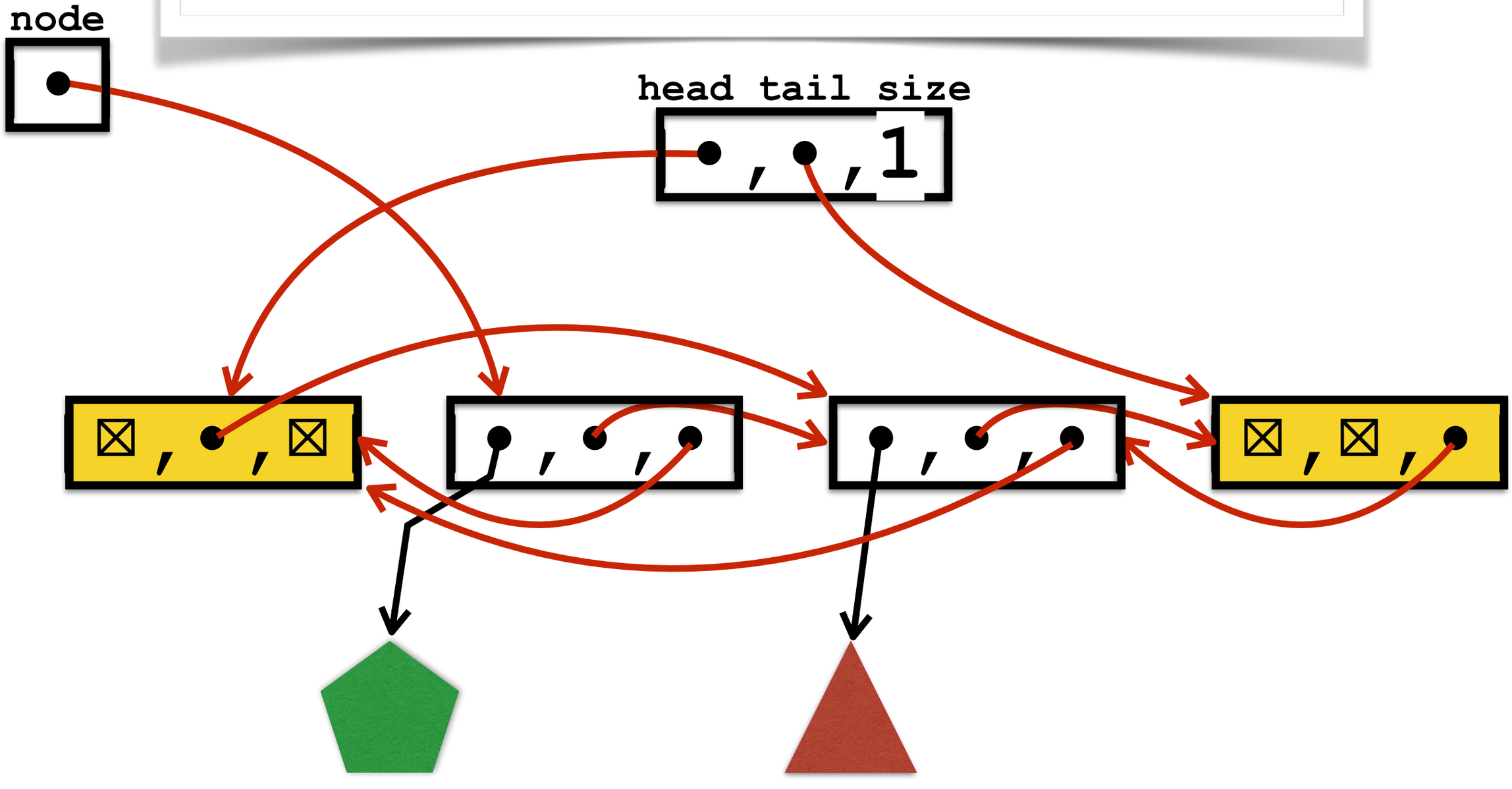

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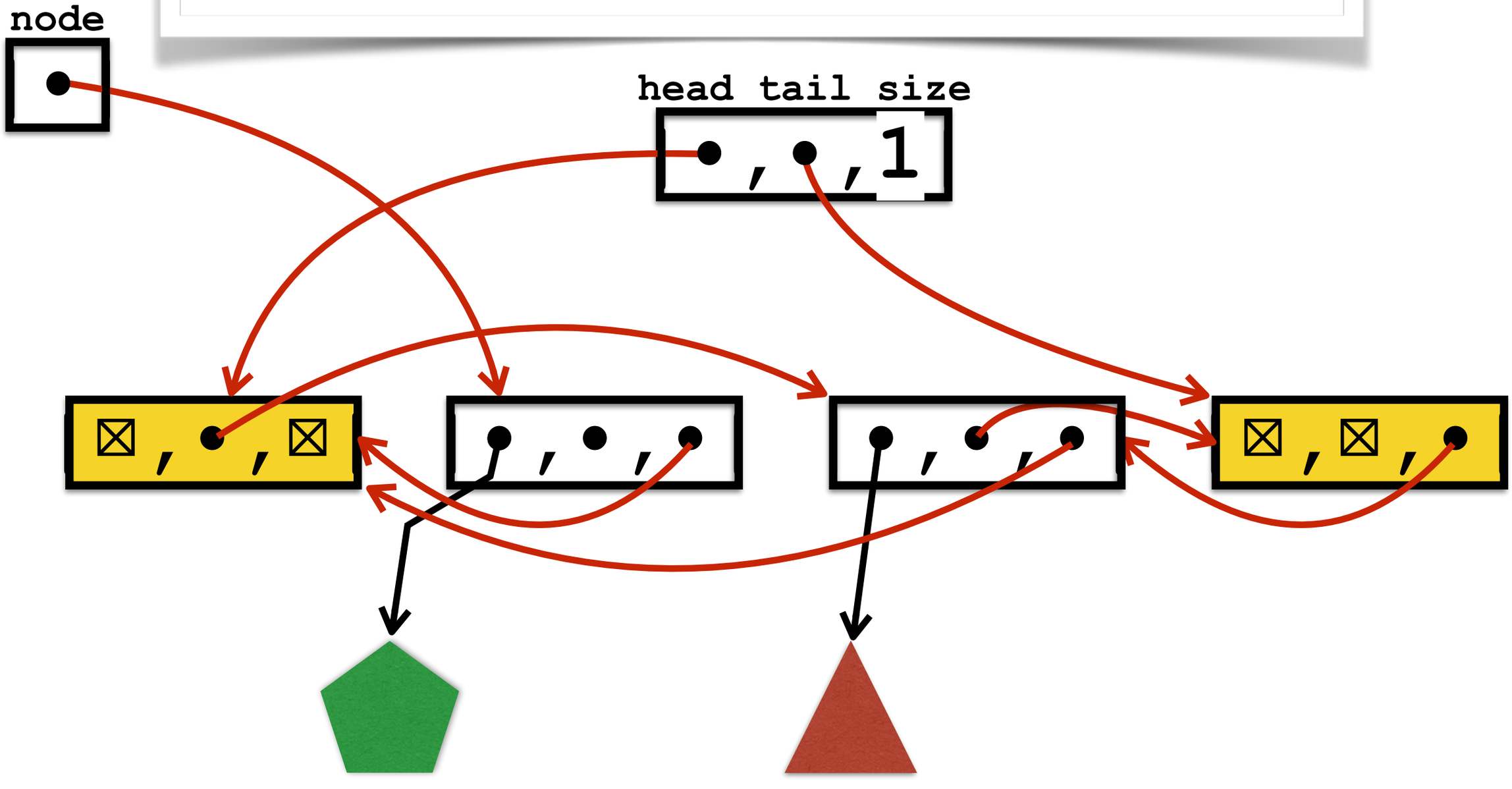

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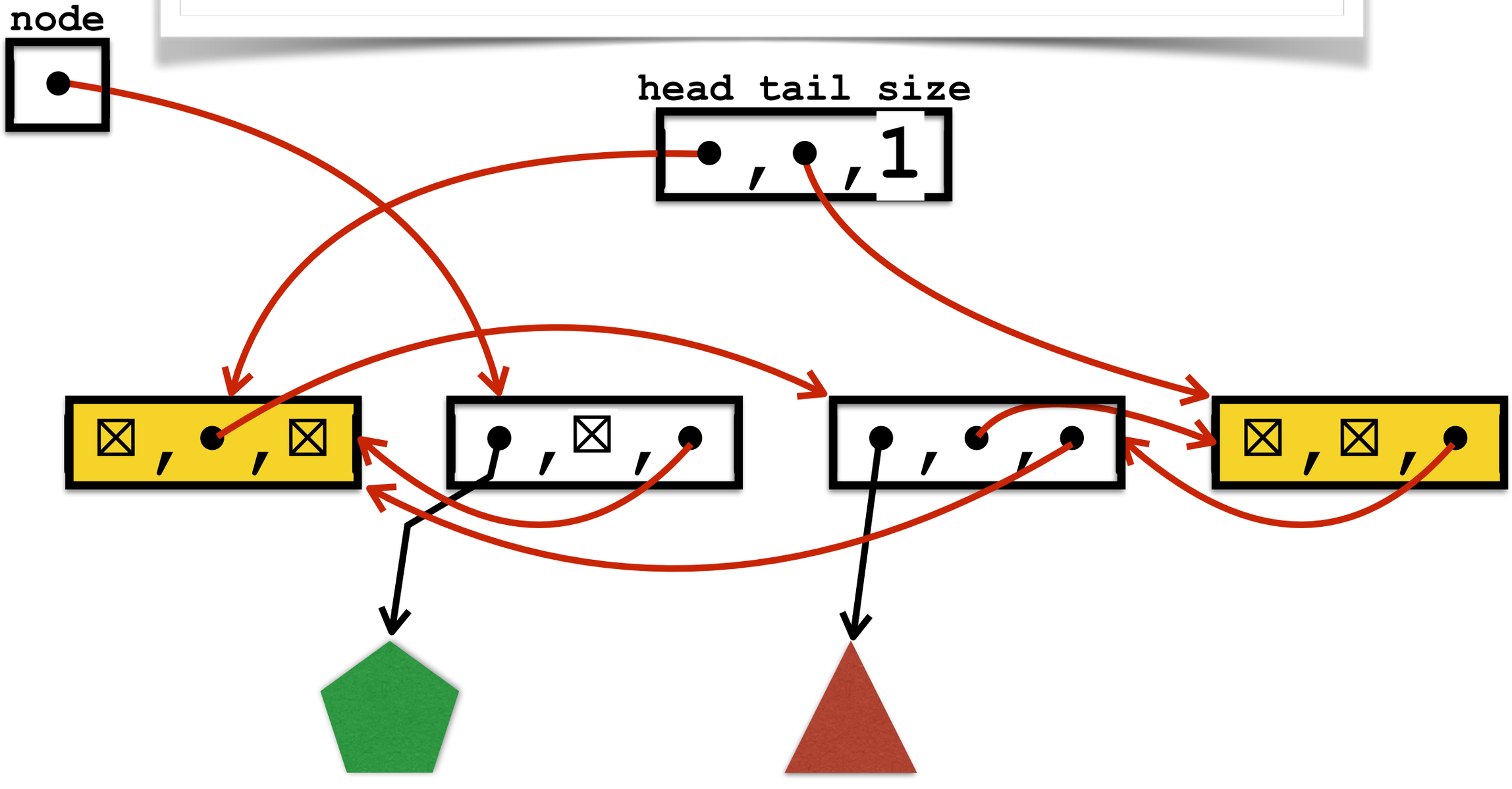

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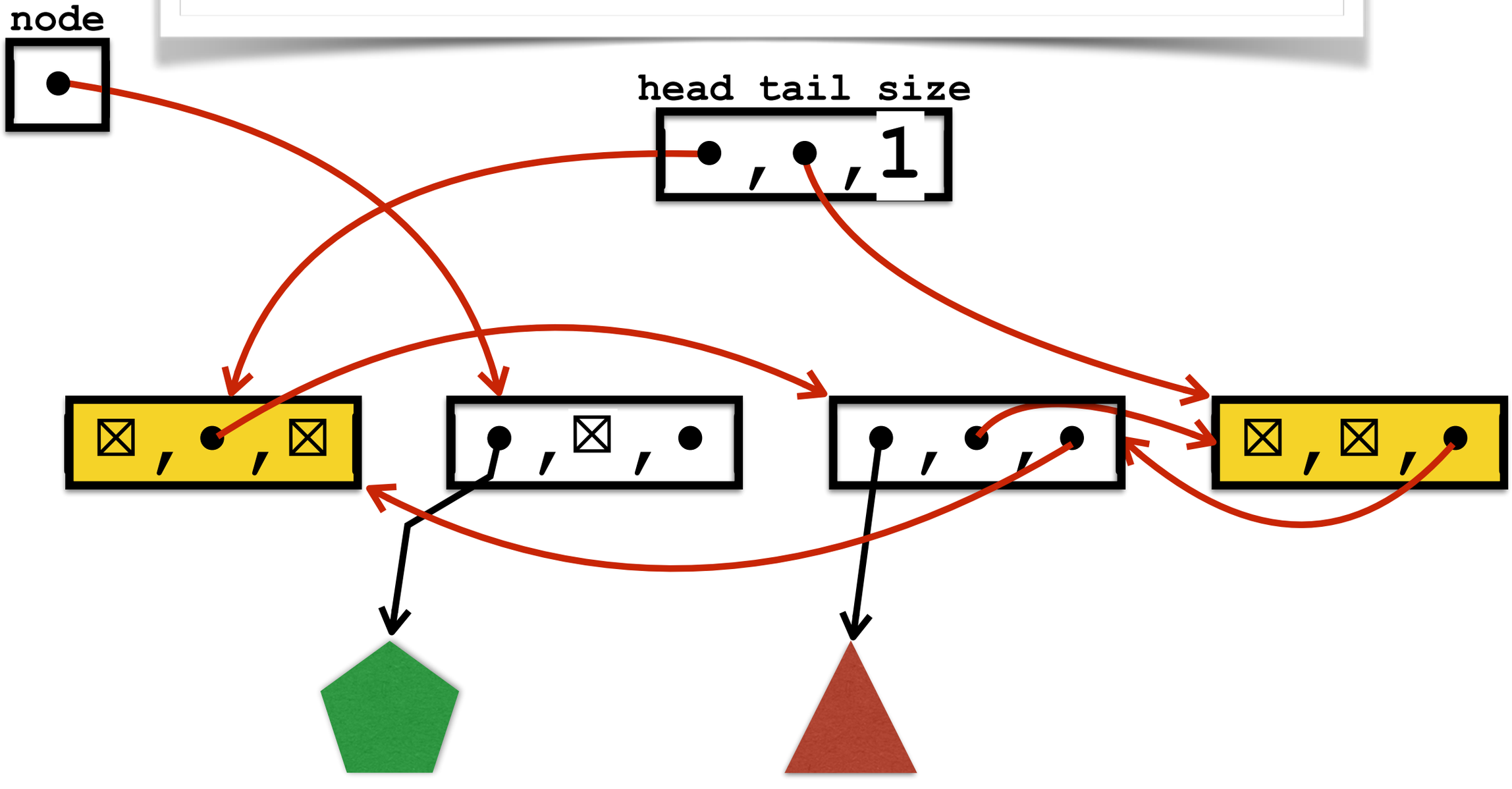

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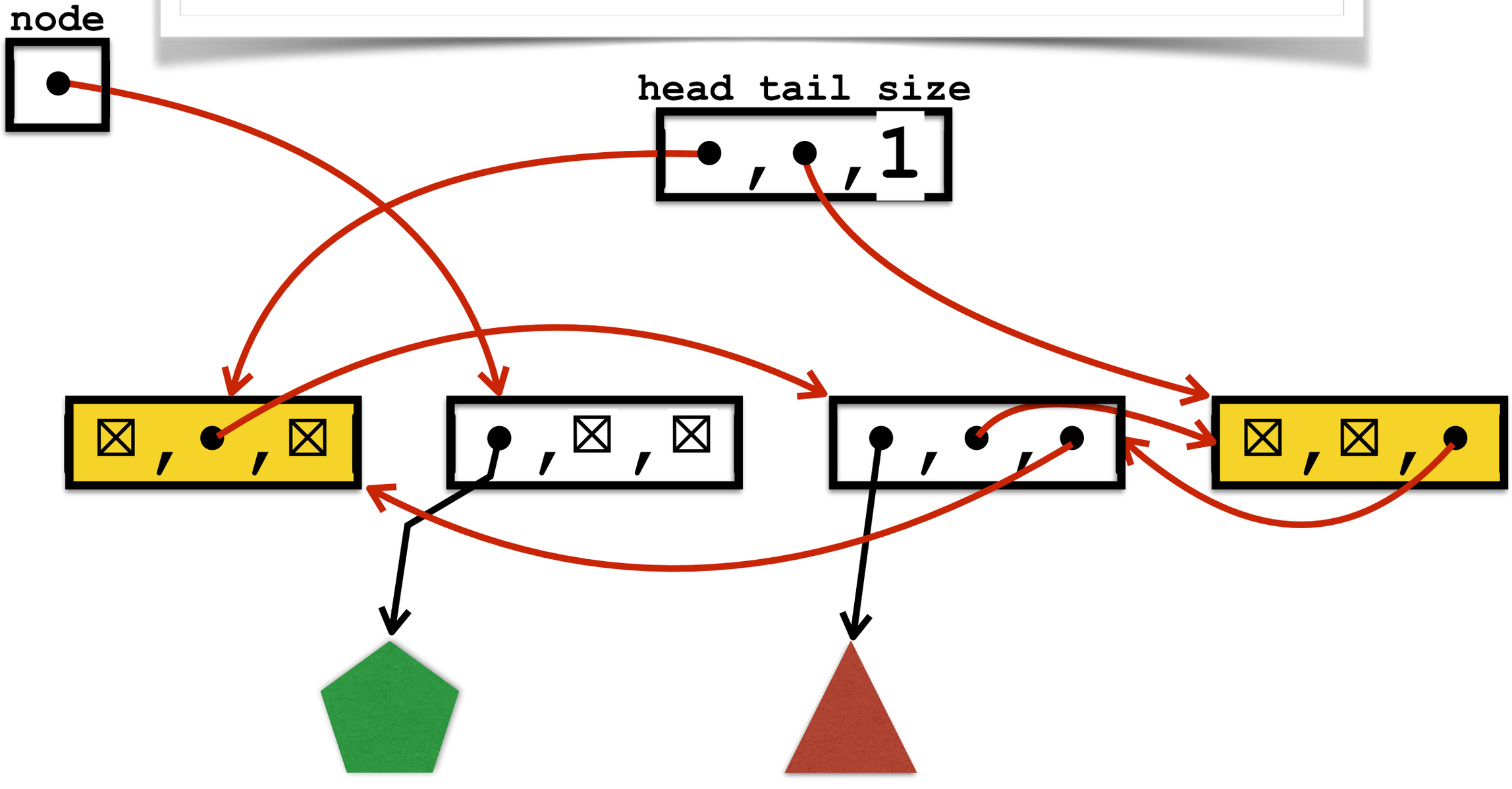


Array vs Linked List

	array	singly linked list	doubly linked list
addFirst	N	1	1
removeFirst	N	1	1
addLast	1	1	1
removeLast	1	N	1
getNode(i)	1	i	min(i, N/2 - i)

Linked Lists as ADT

(Abstract Data Type)

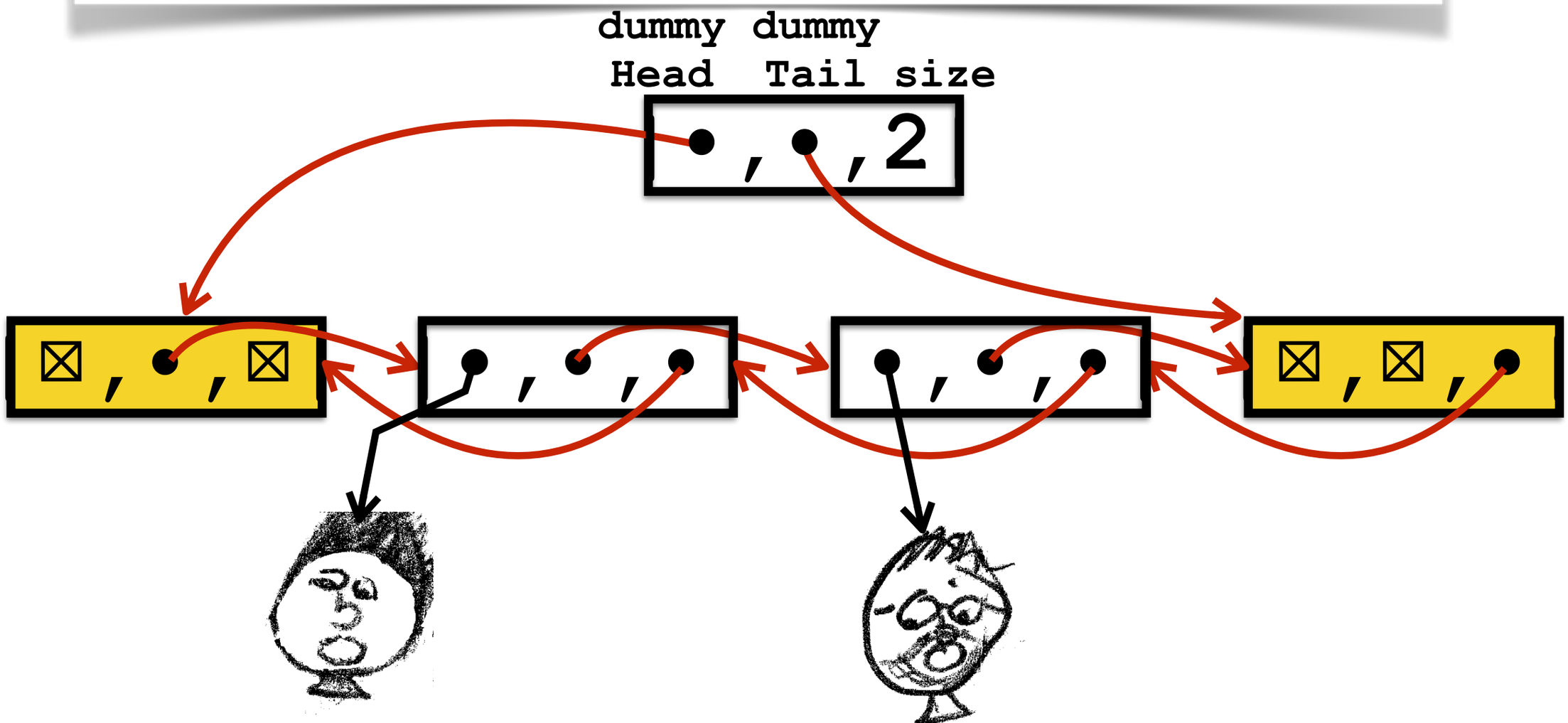
Linked List operations

```
add(i,element)  //  Inserts element into the i-th position
                //  (and increments the indices of elements that were
                //  previously at index i or up)
set(i,element)  //  Replaces the element in the i-th position
remove(i)       //  Removes the i-th element from list
get(i)          //  Returns the i-th element (but doesn't alter list)
clear()         //  Empties list.
isEmpty()       //  Returns true if empty, false if not empty.
size()          //  Returns number of elements in the list
  :
```

```
LinkedList<Student>
studentList  =  new  LinkedList<Student>();
```

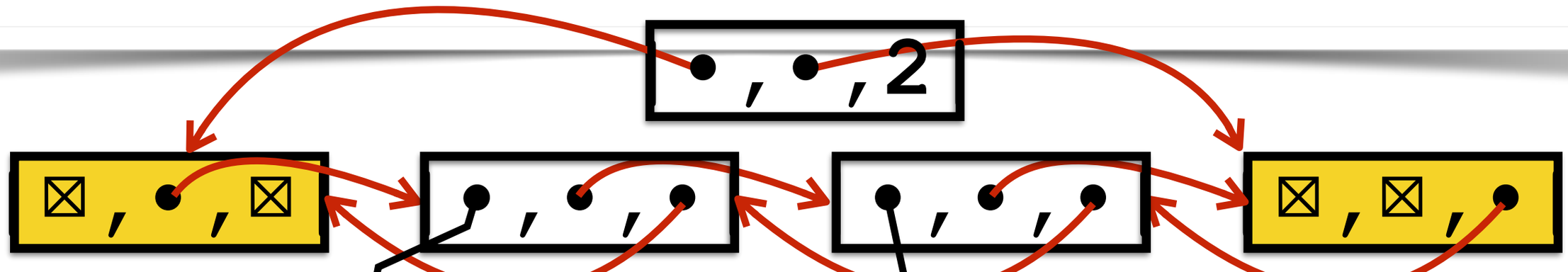
Java LinkedList

- implemented as doubly linked list (with dummies)
- Node class is private



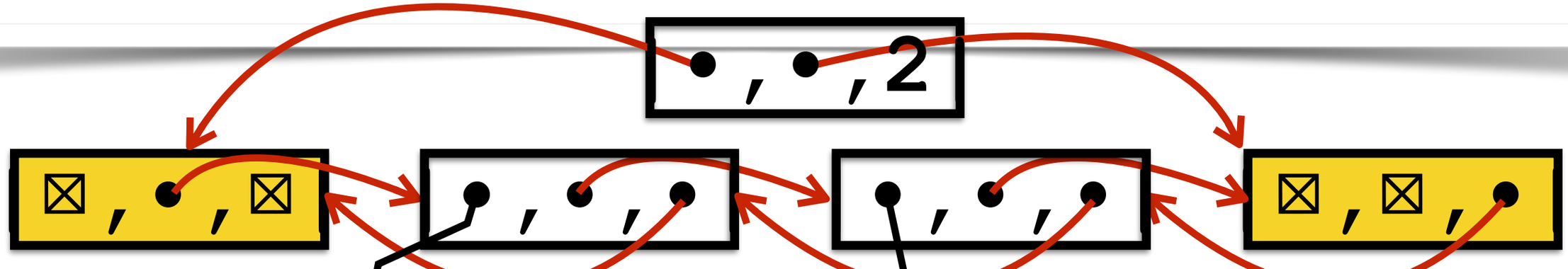
Java LinkedList

	LinkedList
add(element)	1
add(i,element)	n
set(i,element)	n
remove(i)	n
get(i)	n
clear()	1
isEmpty()	1
size()	1



Java LinkedList

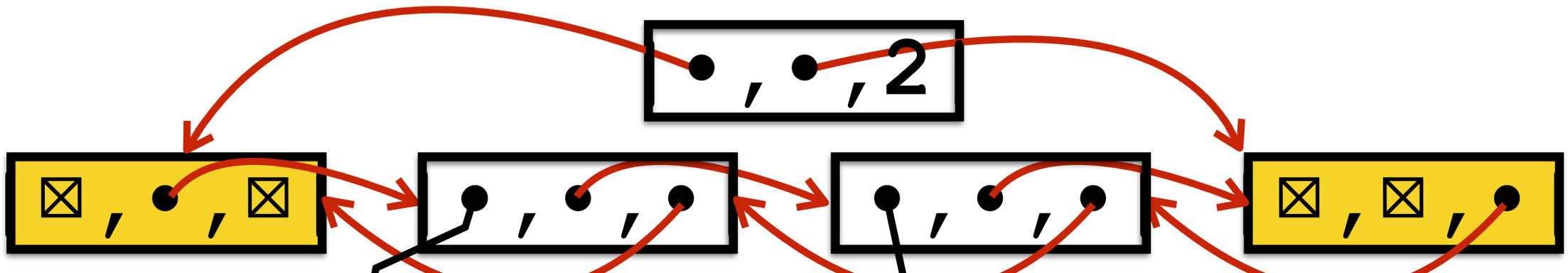
	LinkedList	
add(element)	1	
add(i,element)	n	expensive
set(i,element)	n	
remove(i)	n	
get(i)	n	
clear()	1	
isEmpty()	1	
size()	1	



Java LinkedList

```
for (j = 1; j < n;  j++)
    print( studentList.get(j) )
```

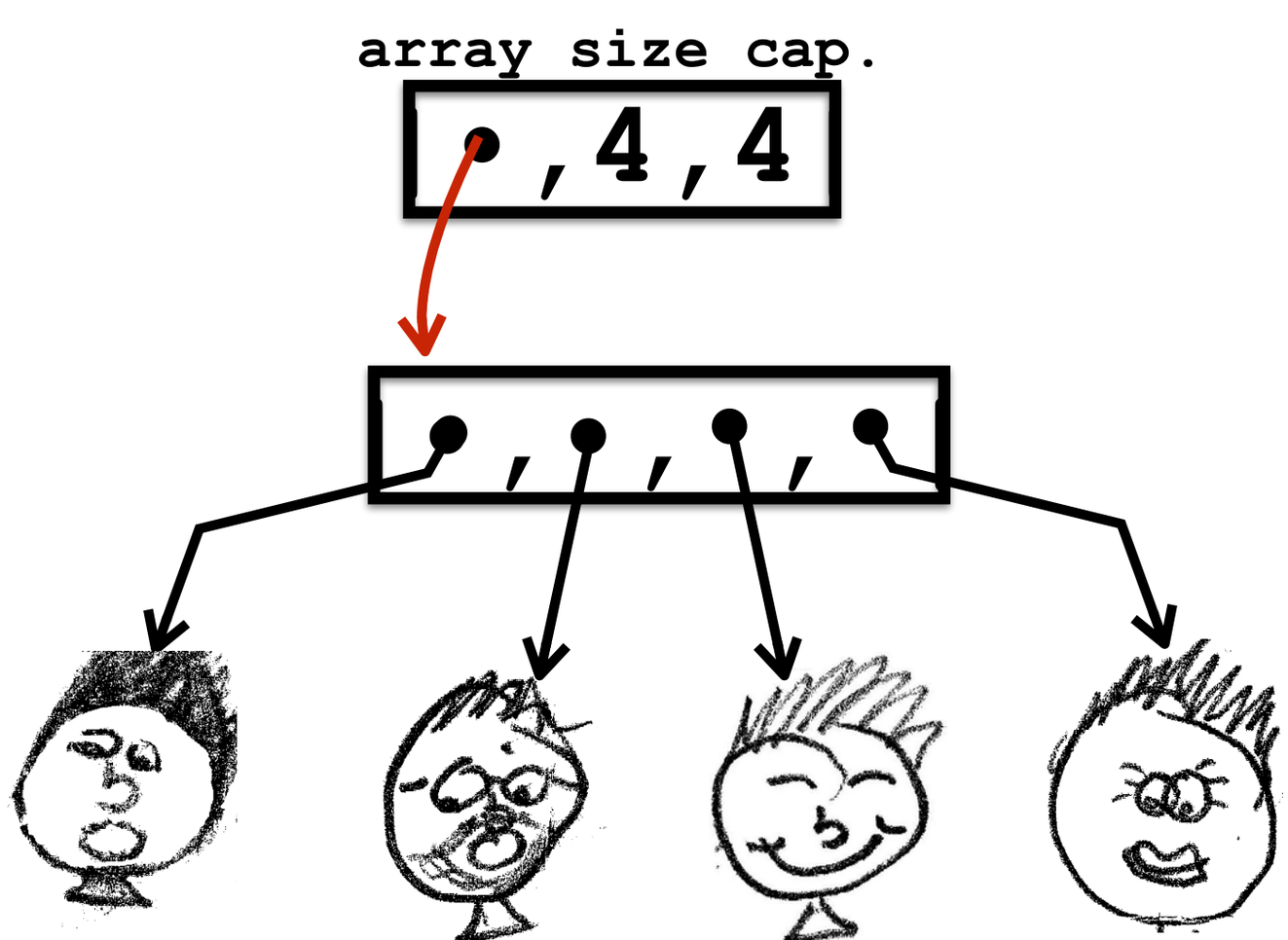
Time(n) **is** $\Omega(n^2)$



Java ArrayList

- implementation using arrays of growing sizes
- cannot access using a[i] notation

```
add(element)
add(i,element)
set(i,element)
remove(i)
get(i)
clear()
isEmpty()
size()
```



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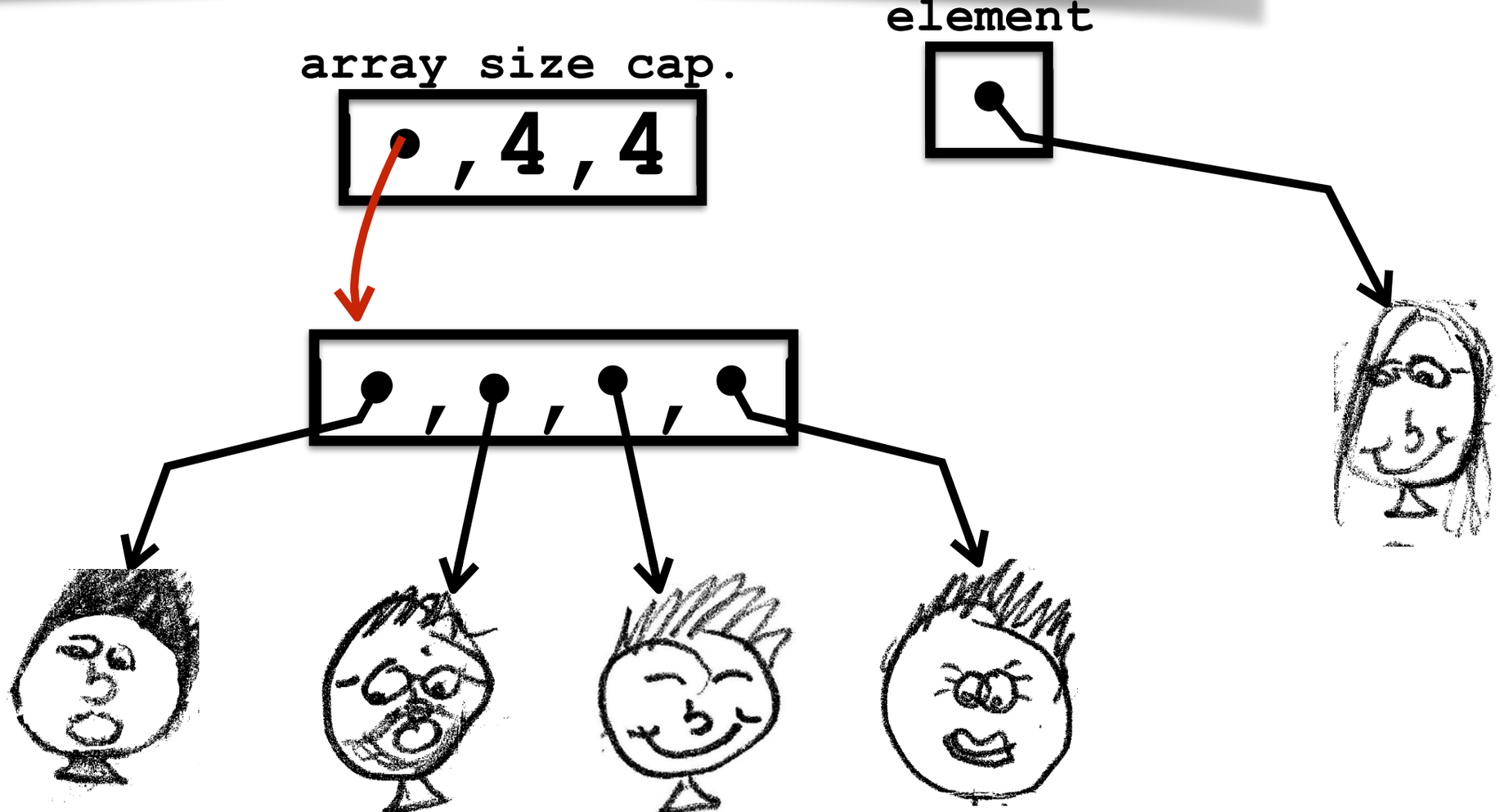
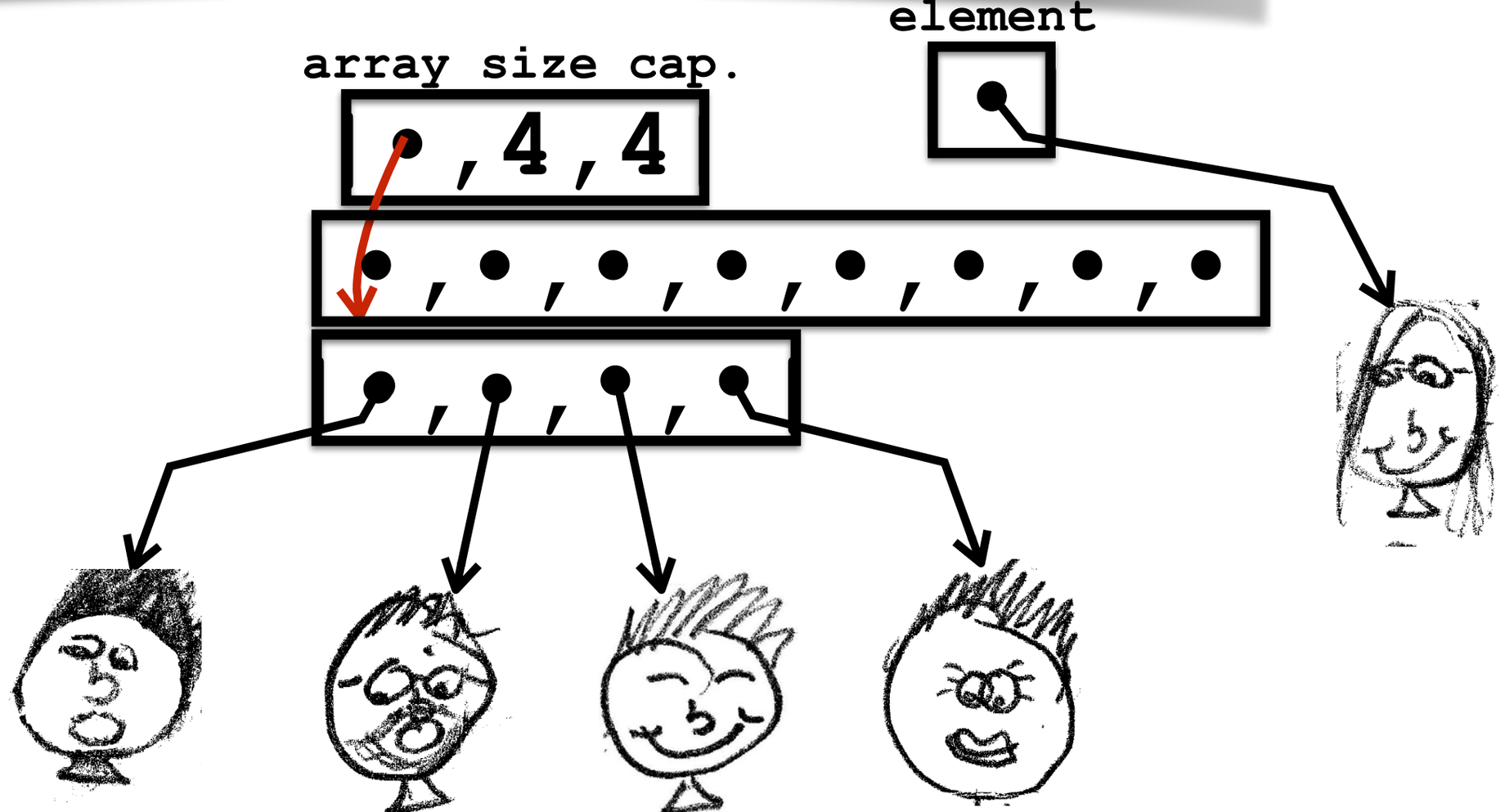


Java ArrayList

- when new space is needed - doubles the array size.

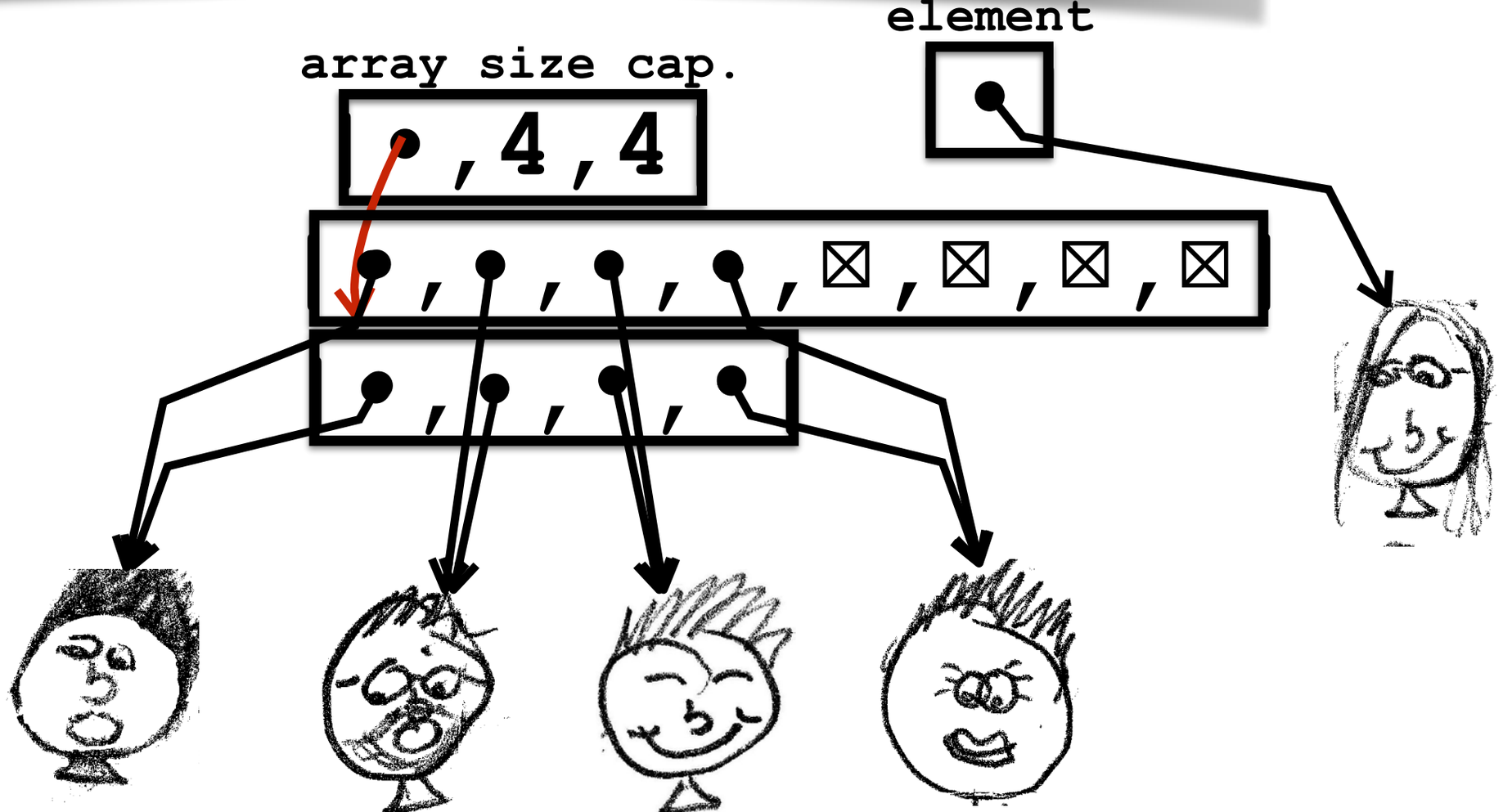
```
add(element)
add(i,element)
set(i,element)
remove(i)
get(i)
clear()
isEmpty()
size()
```



Java ArrayList

- smaller array is copied into bigger array.

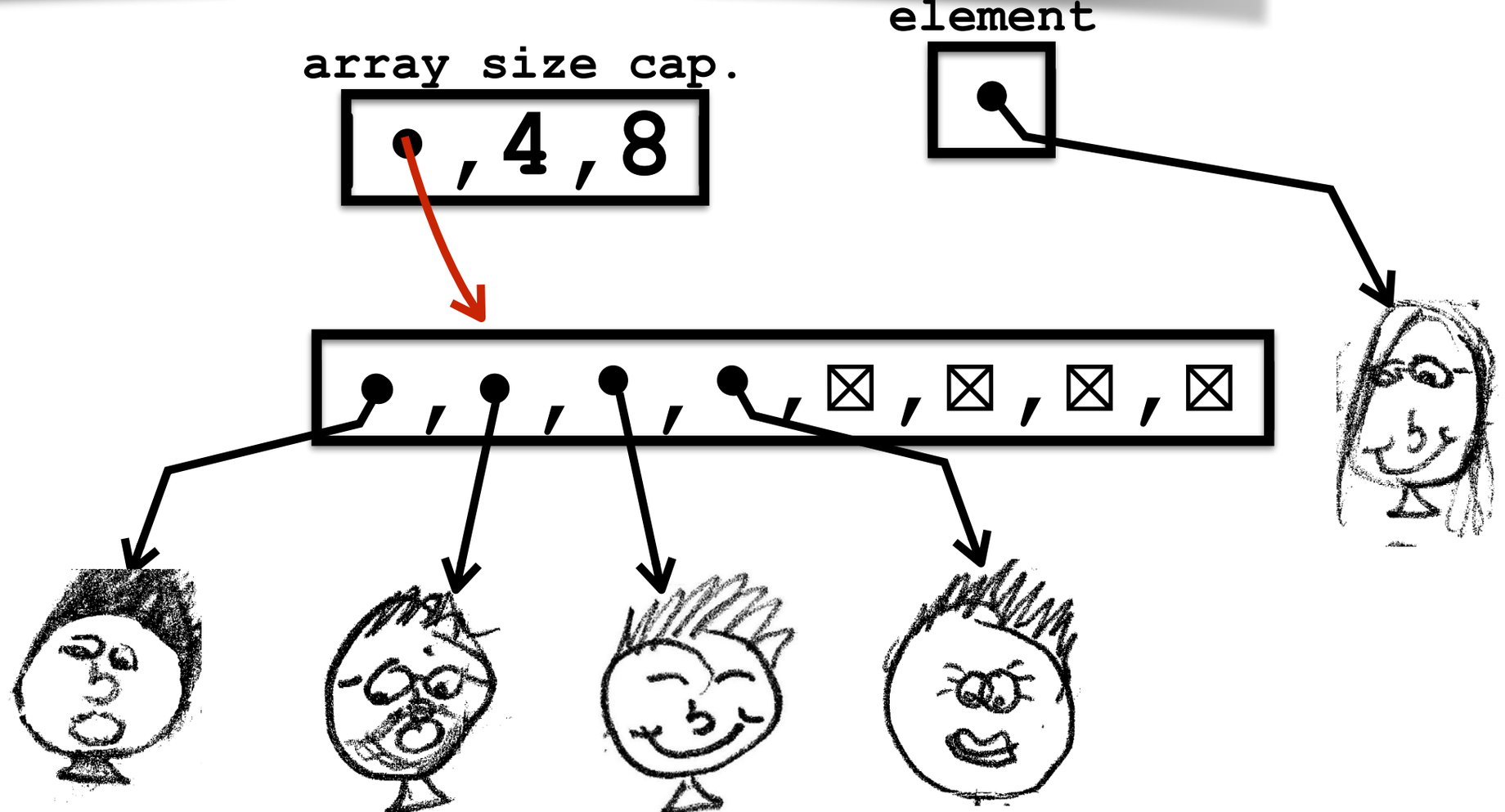
```
add(element)
add(i,element)
set(i,element)
remove(i)
get(i)
clear()
isEmpty()
size()
```



Java ArrayList

- new element added to new array

```
add(element)
add(i,element)
set(i,element)
remove(i)
get(i)
clear()
isEmpty()
size()
```



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get(i)
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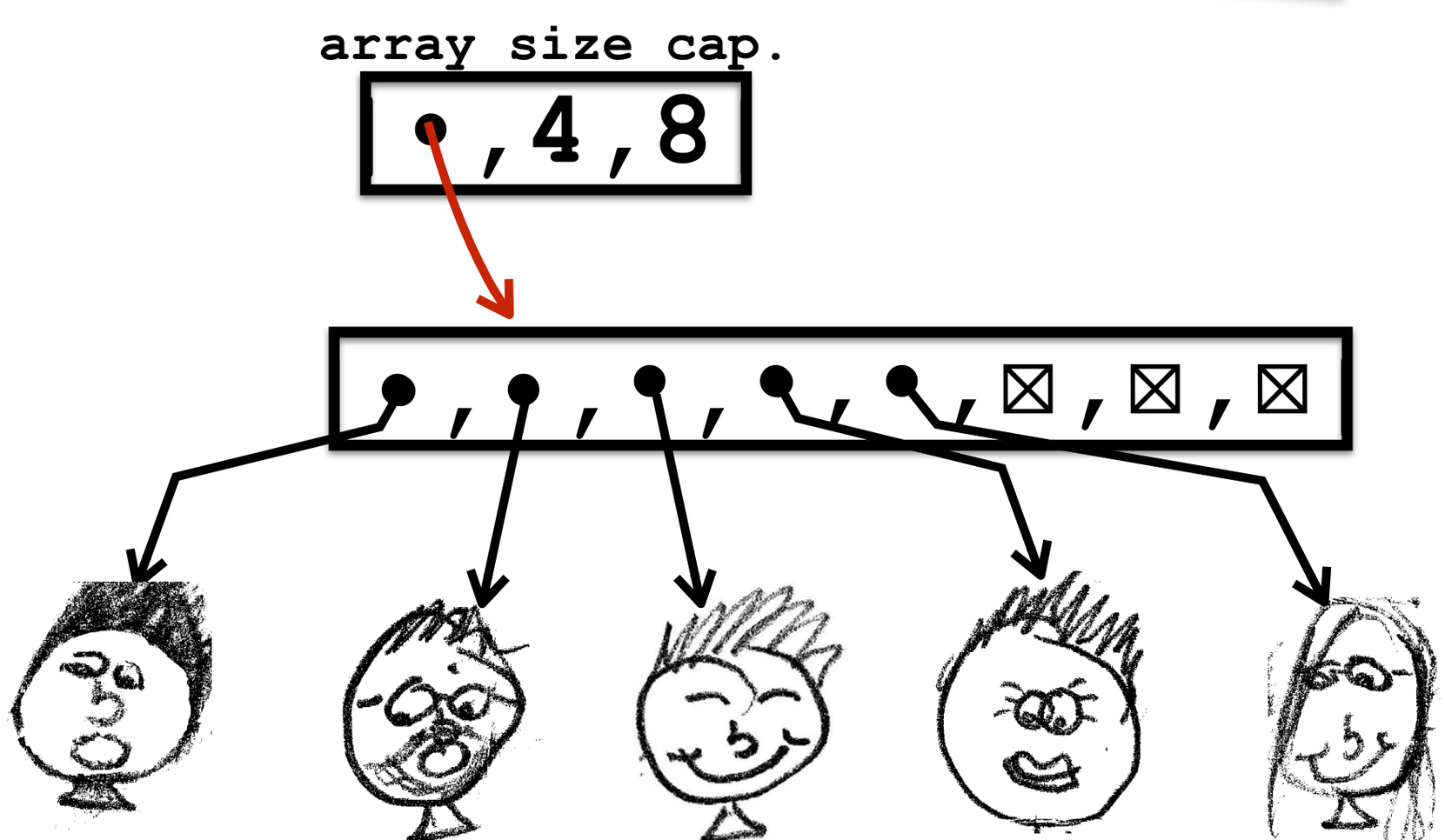
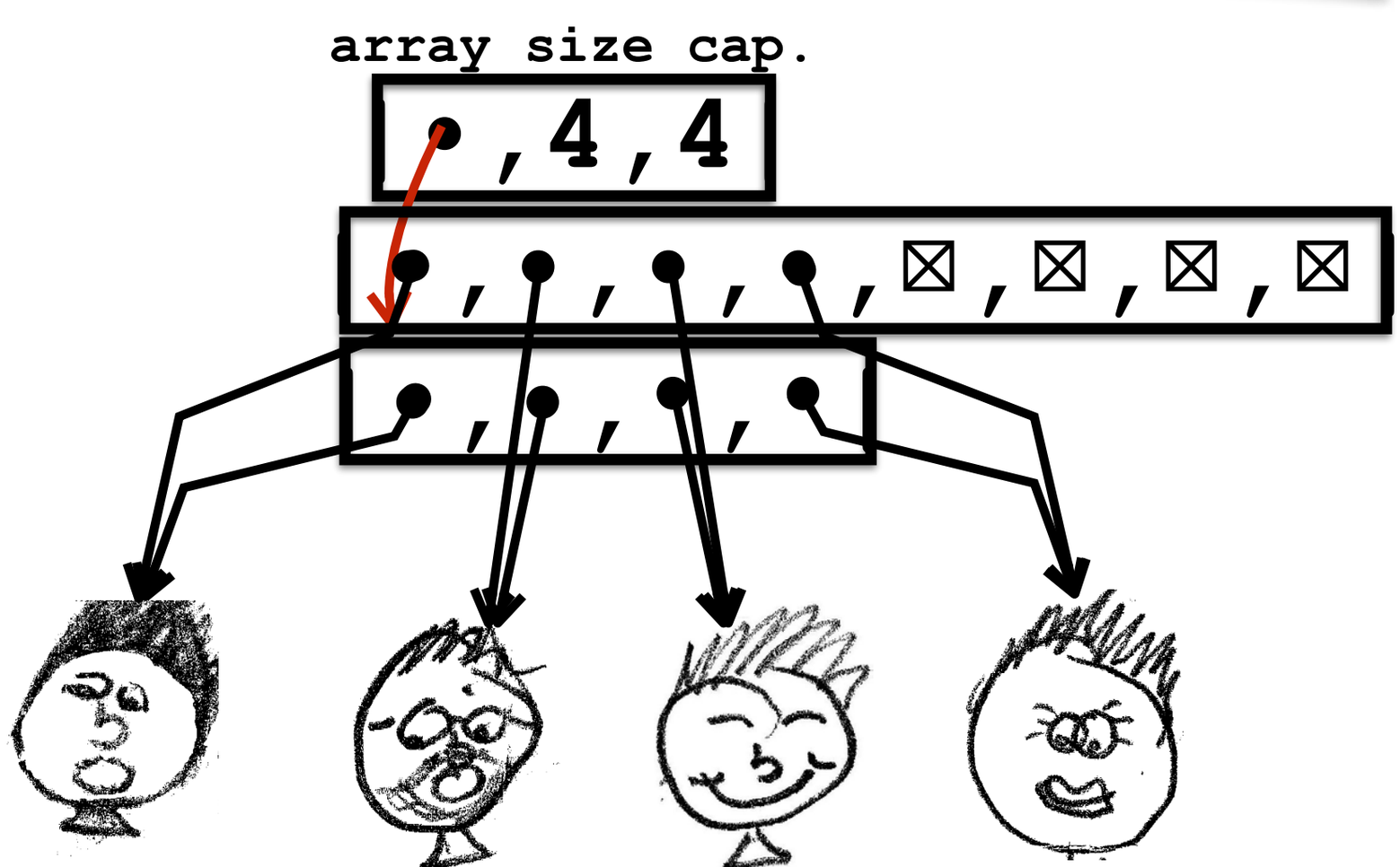


Cost ?

Java ArrayList

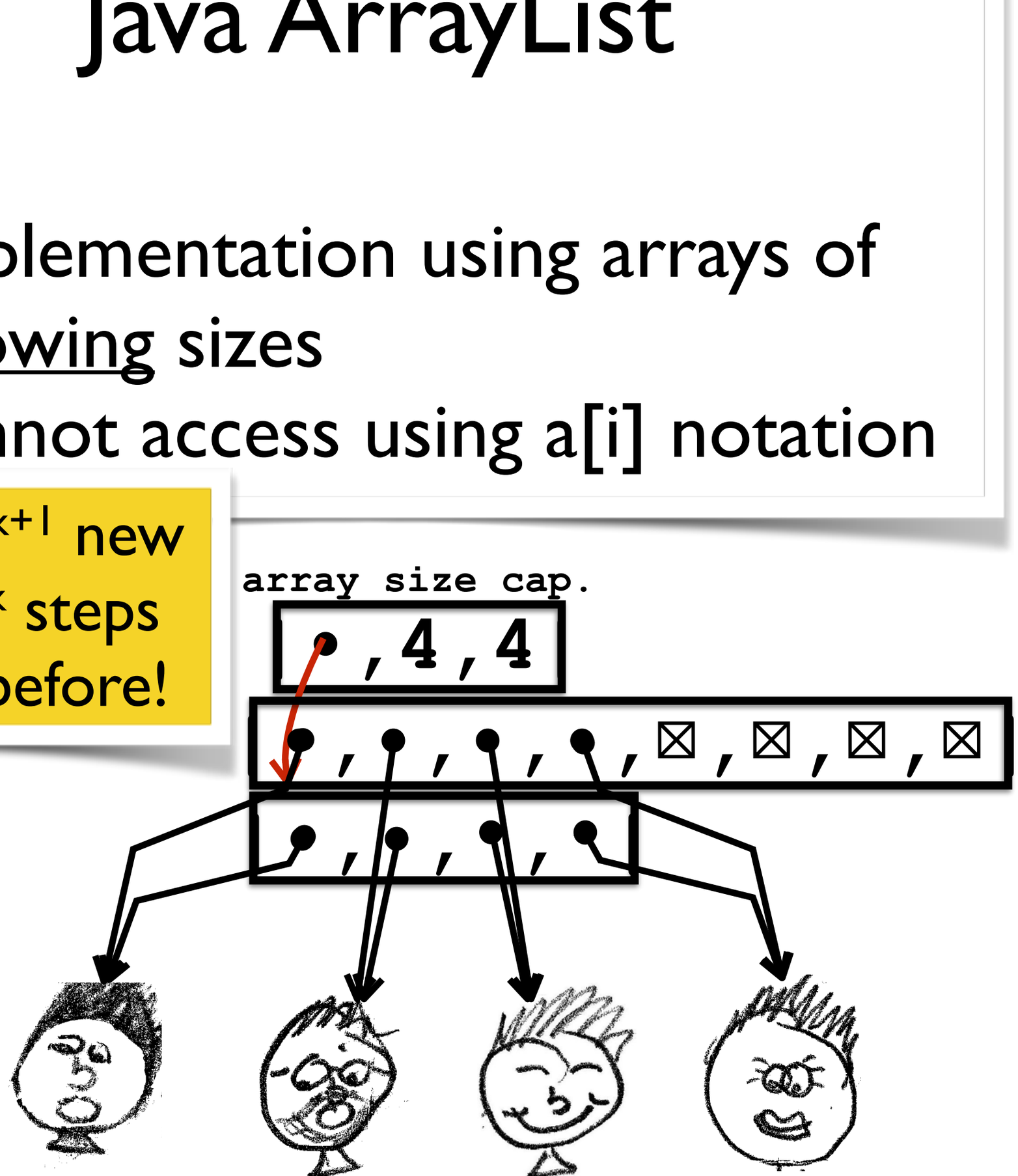
- implementation using arrays of growing sizes
- cannot access using a[i] notation



Java ArrayList

- implementation using arrays of growing sizes
- cannot access using a[i] notation

Extra cost of 2^{k+1} new steps only if 2^k steps already spent before!



Java ArrayList

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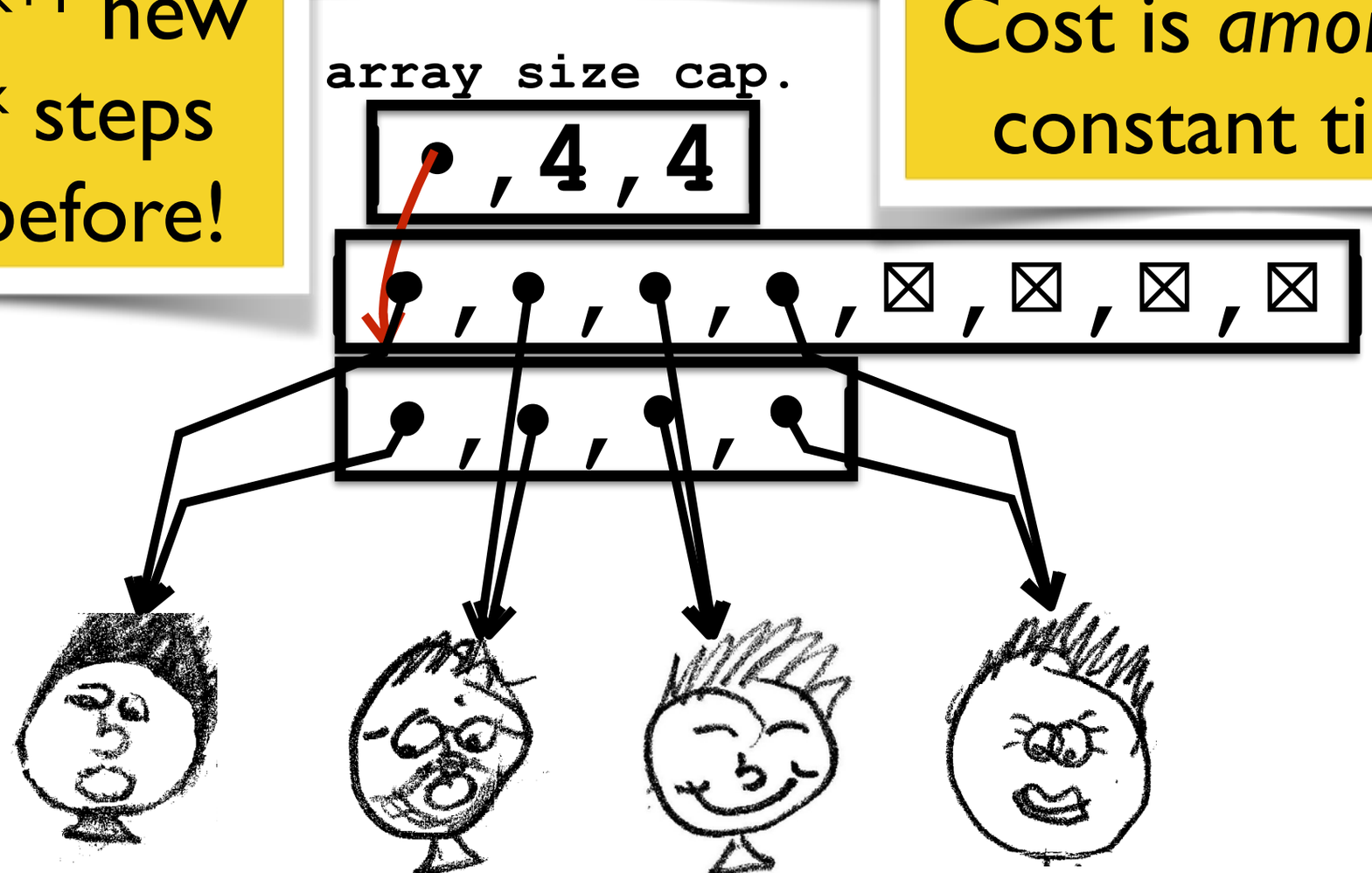
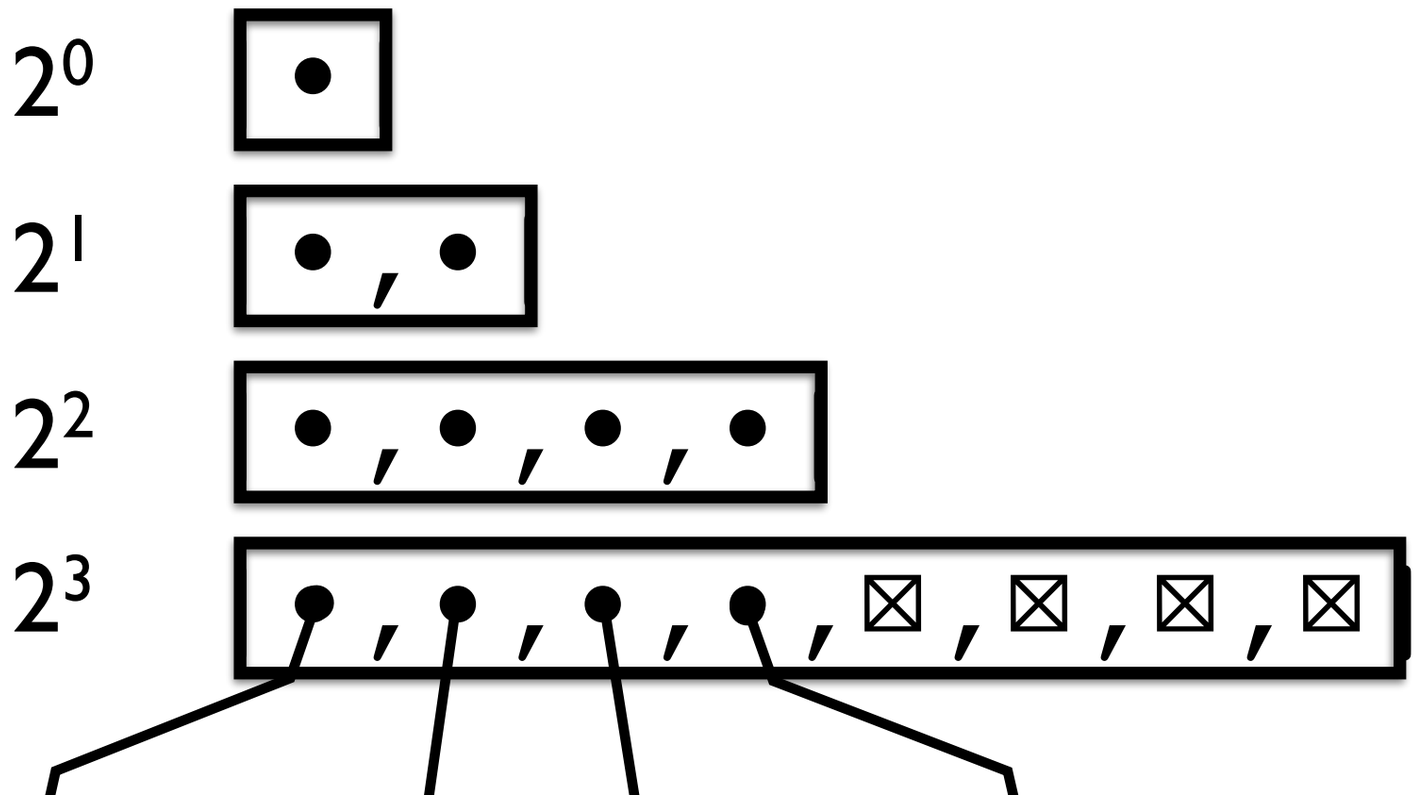
Extra cost of 2^{k+1} new steps only if 2^k steps already spent before!

Cost is *amortized* constant time!

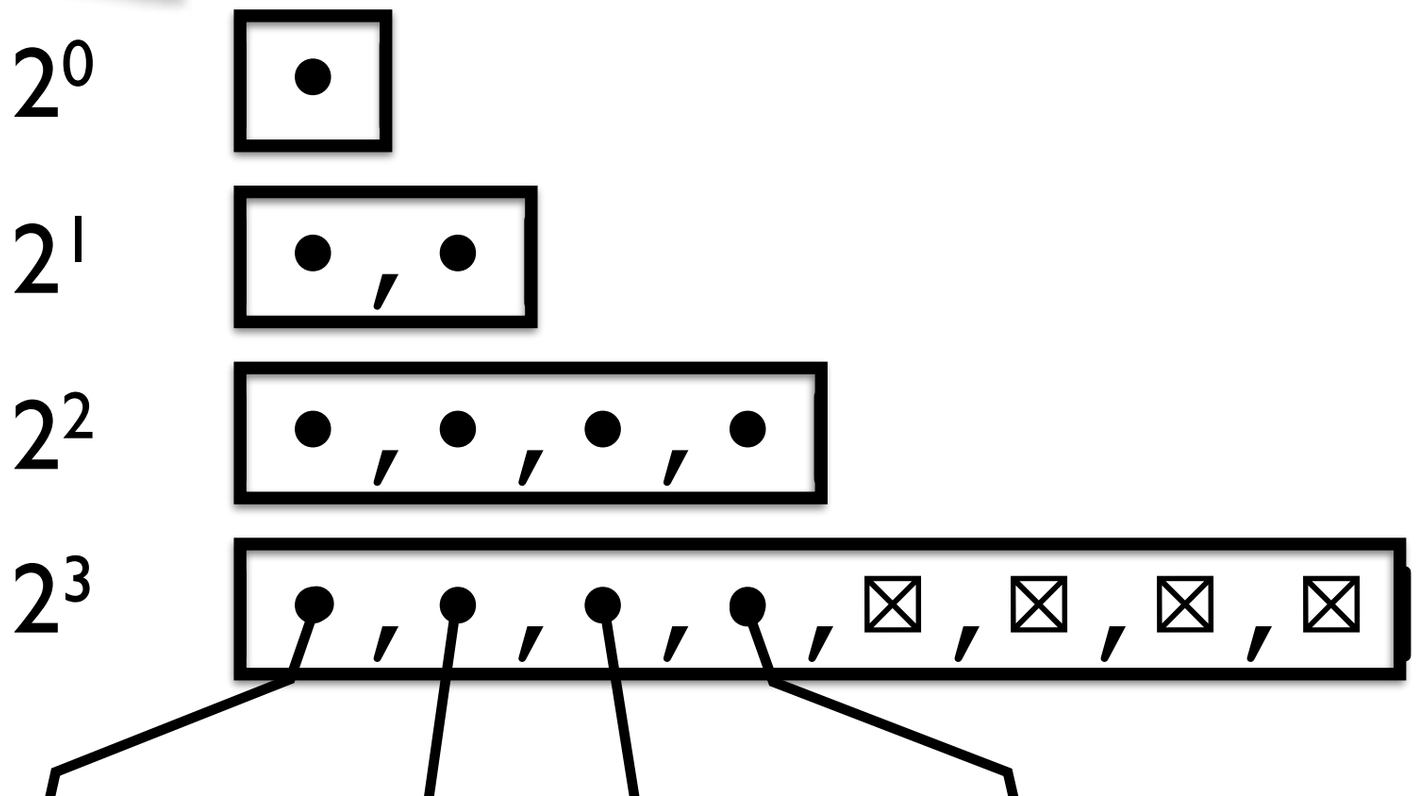


Java ArrayList



Java ArrayList

To build an array of 2^k elements you need $2^{k+1}-1$ steps!



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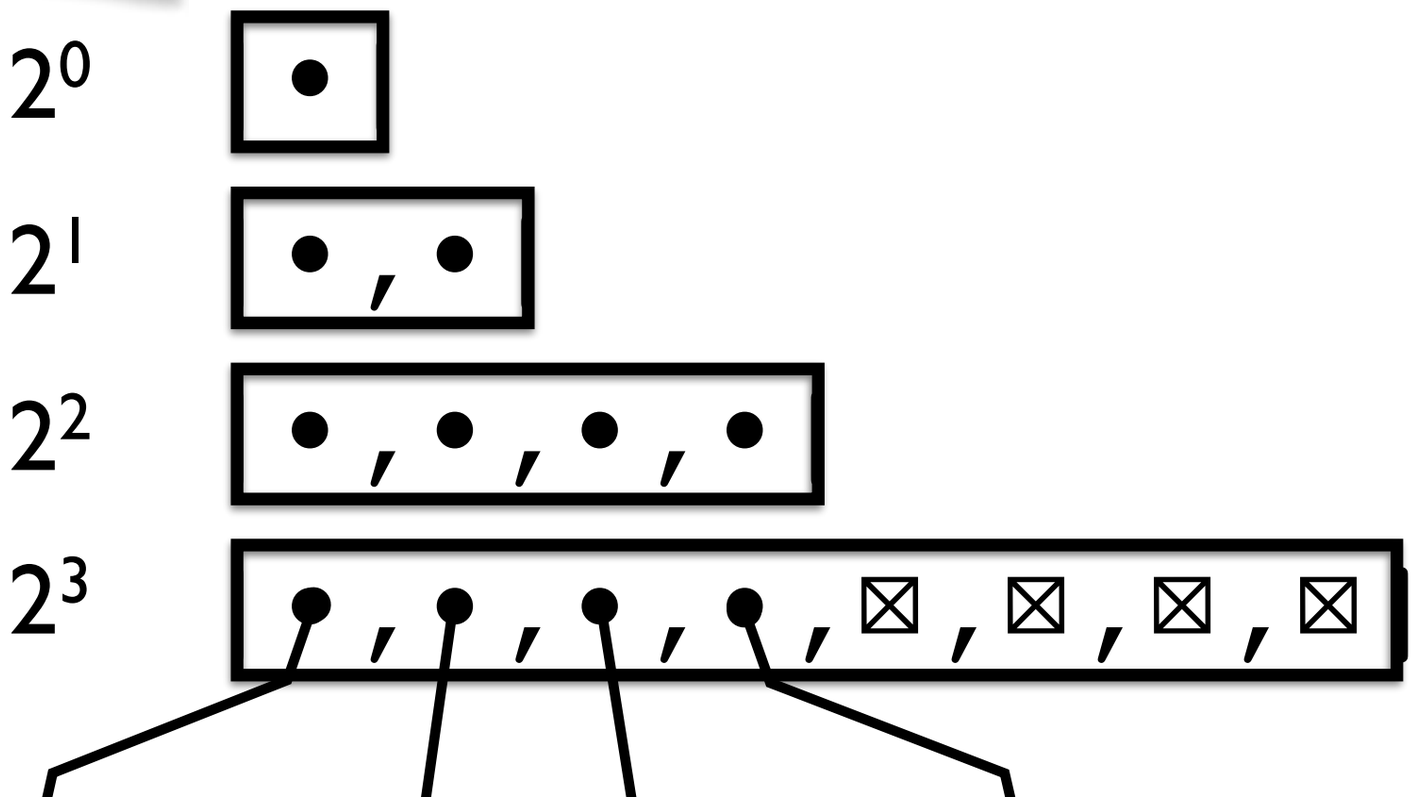

Java ArrayList

- implementation using arrays of growing sizes
- cannot access using a[i] notation

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add(element)
add(i,element)
set(i,element)
remove(i)
get(i)
clear()
isEmpty()
size()
```

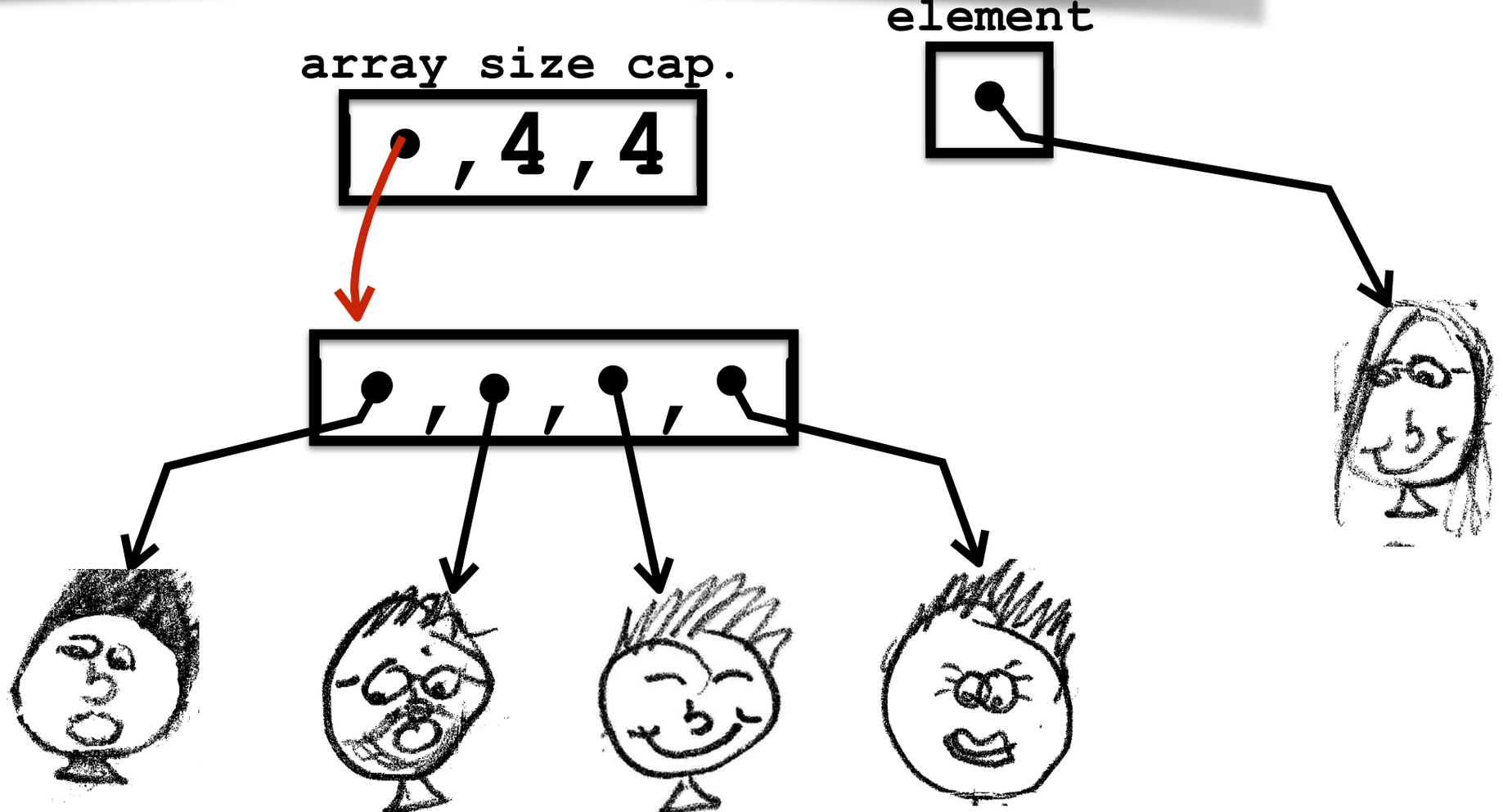

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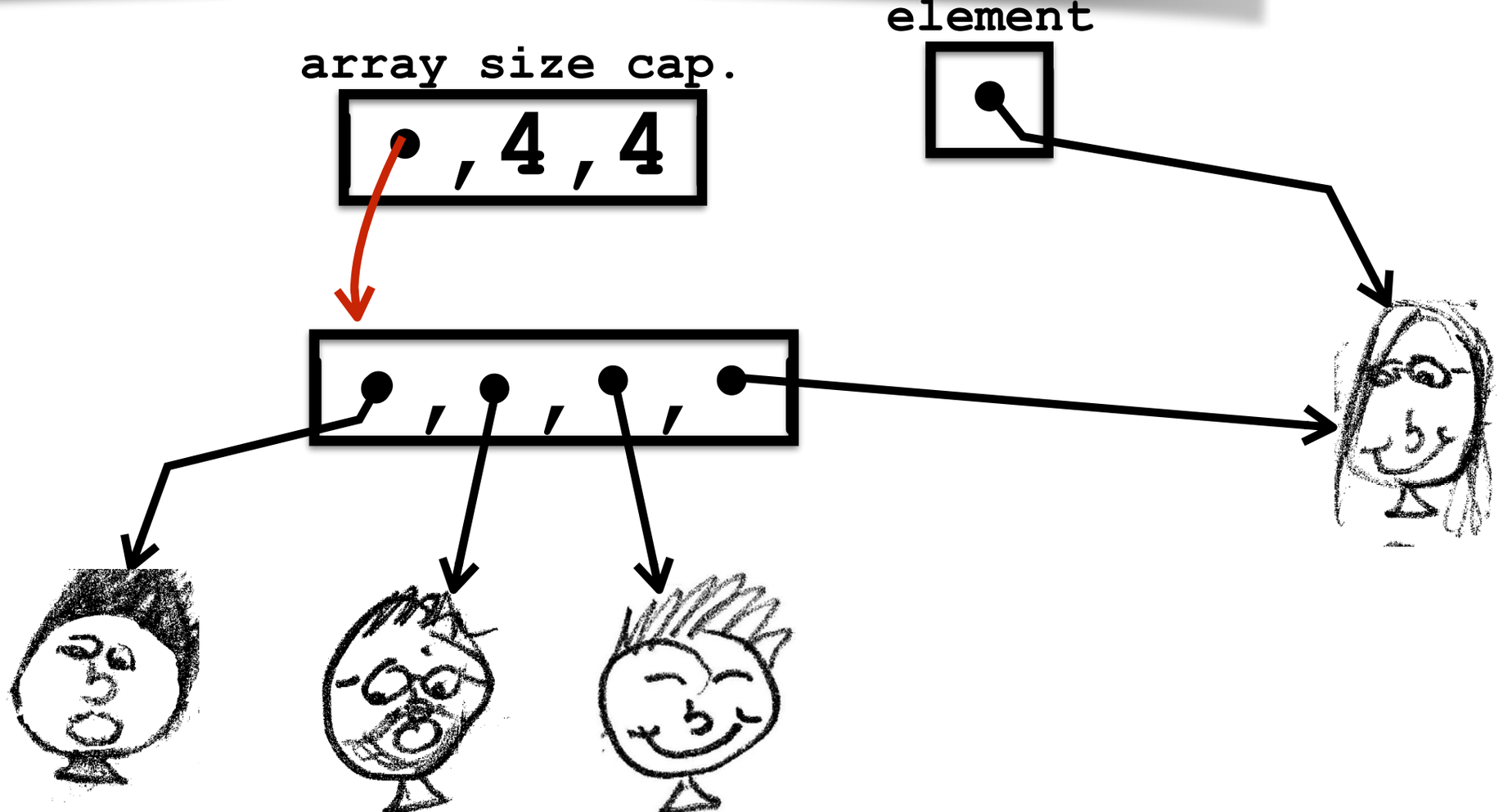

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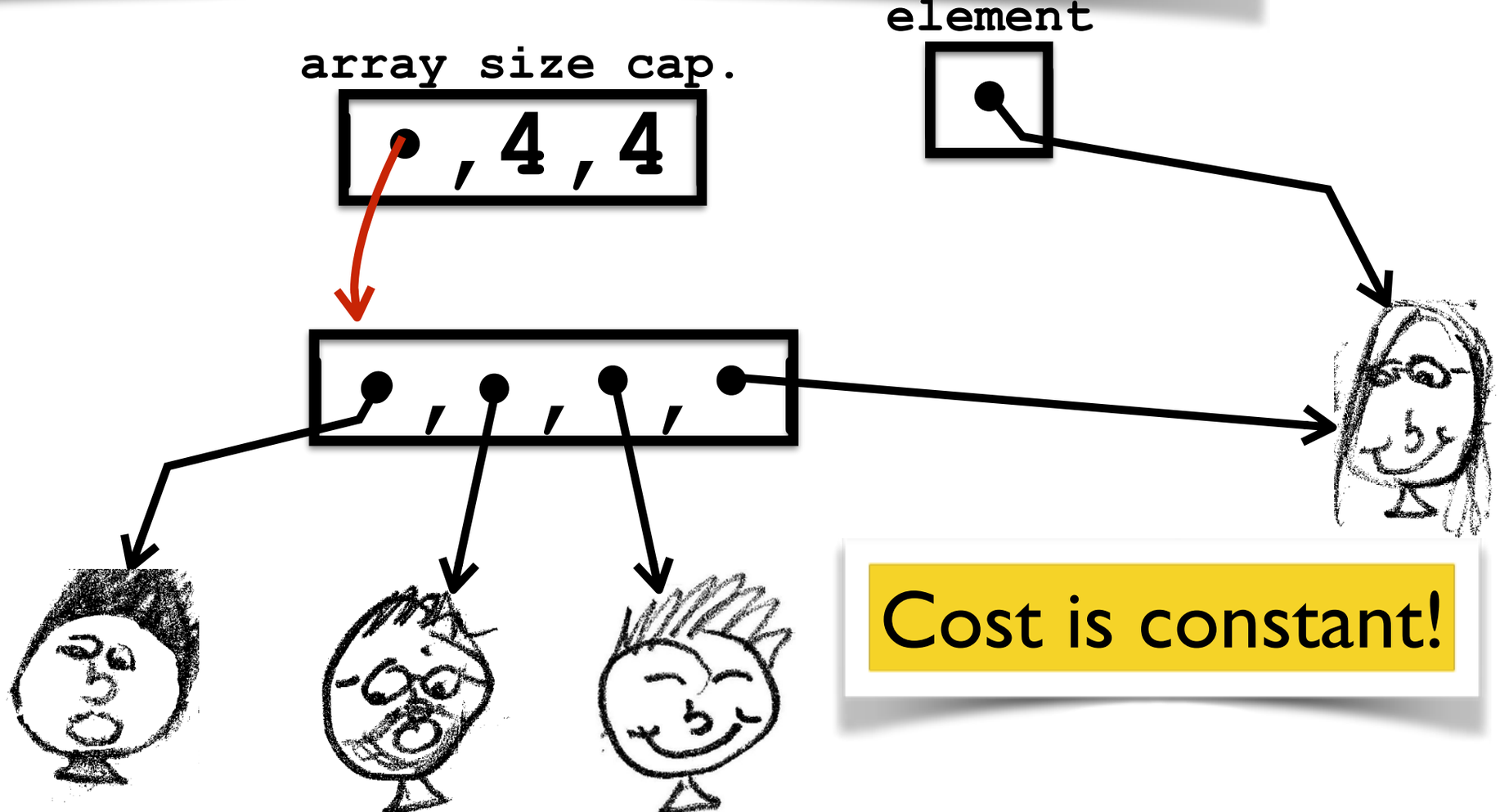

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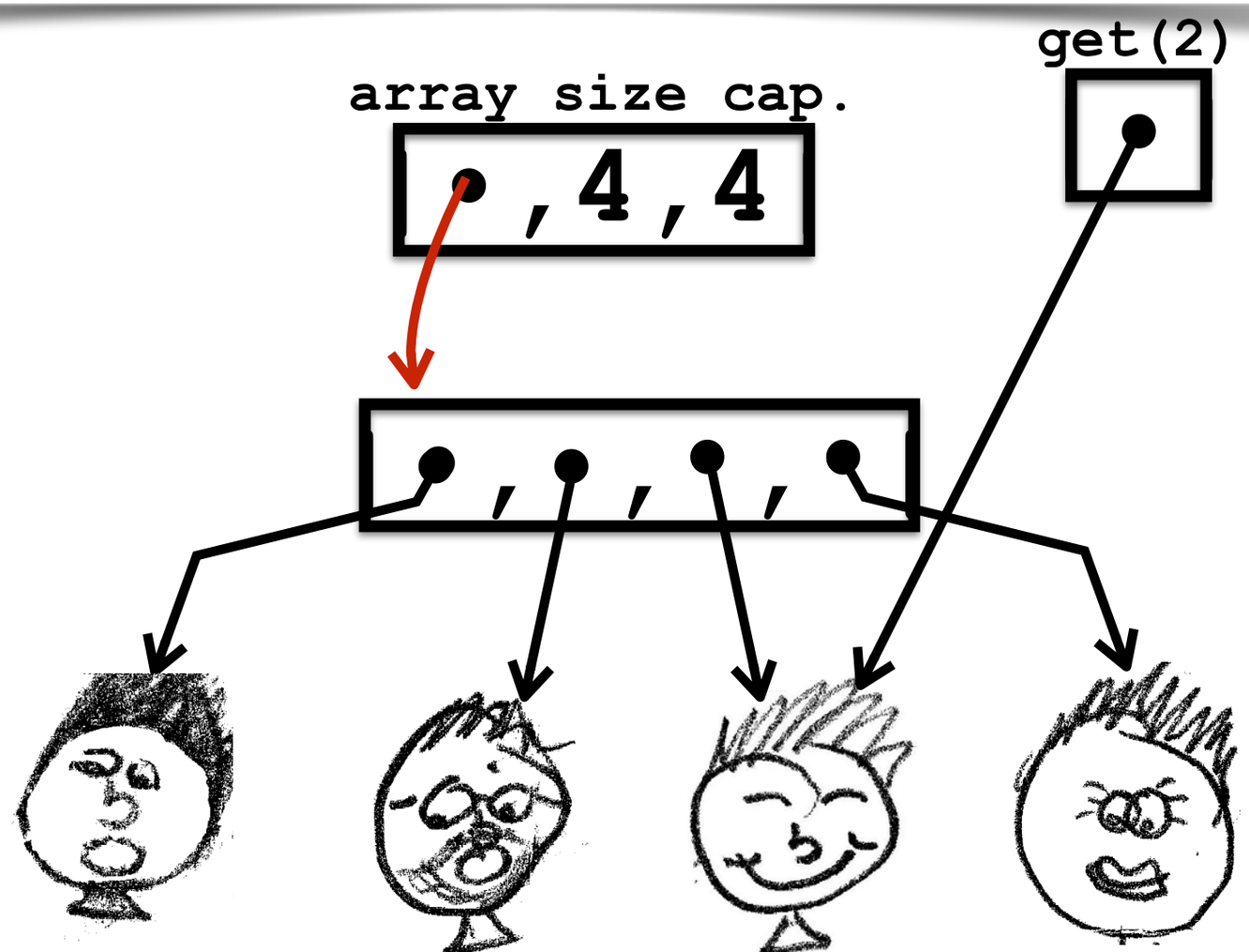

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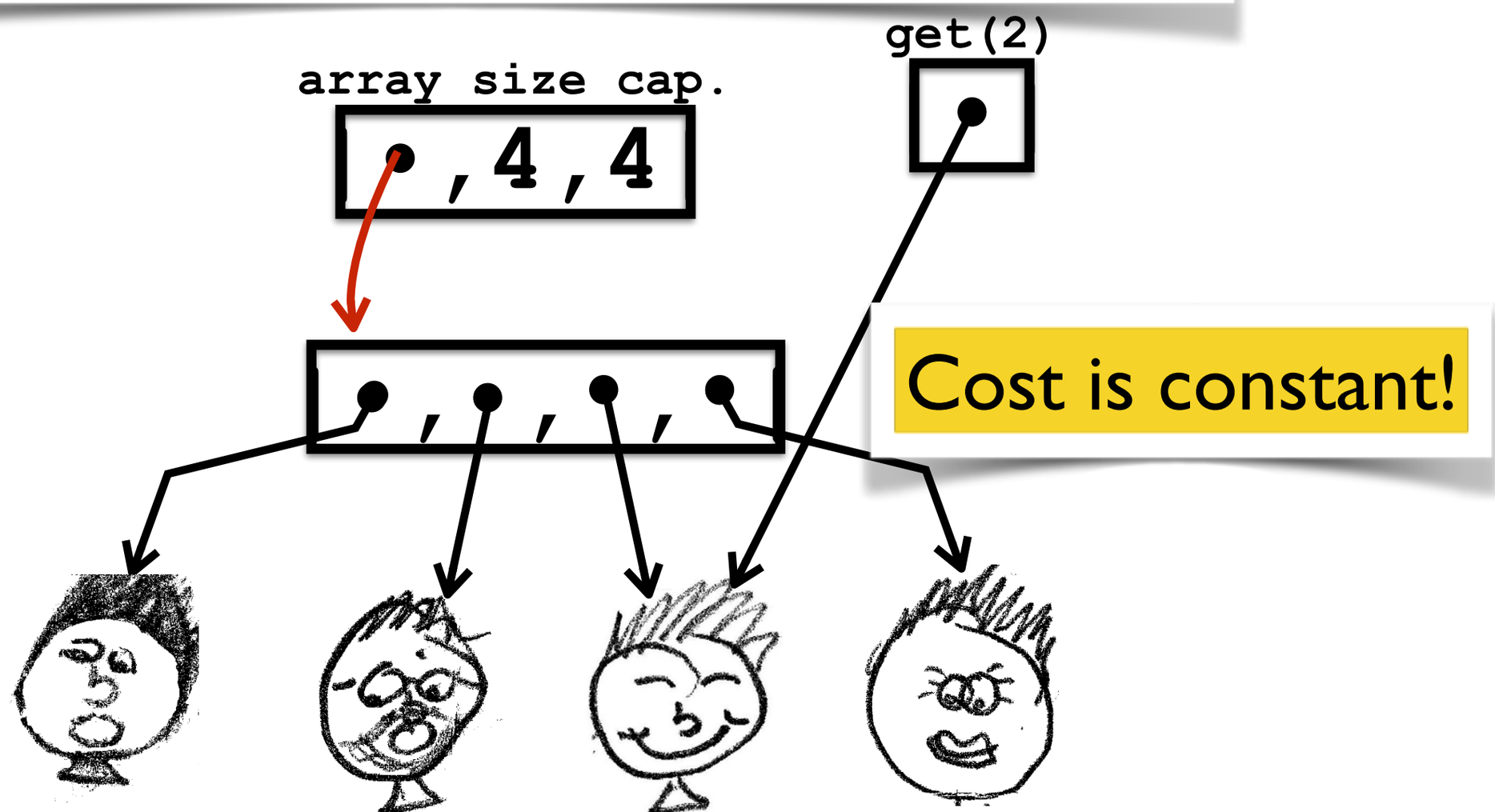

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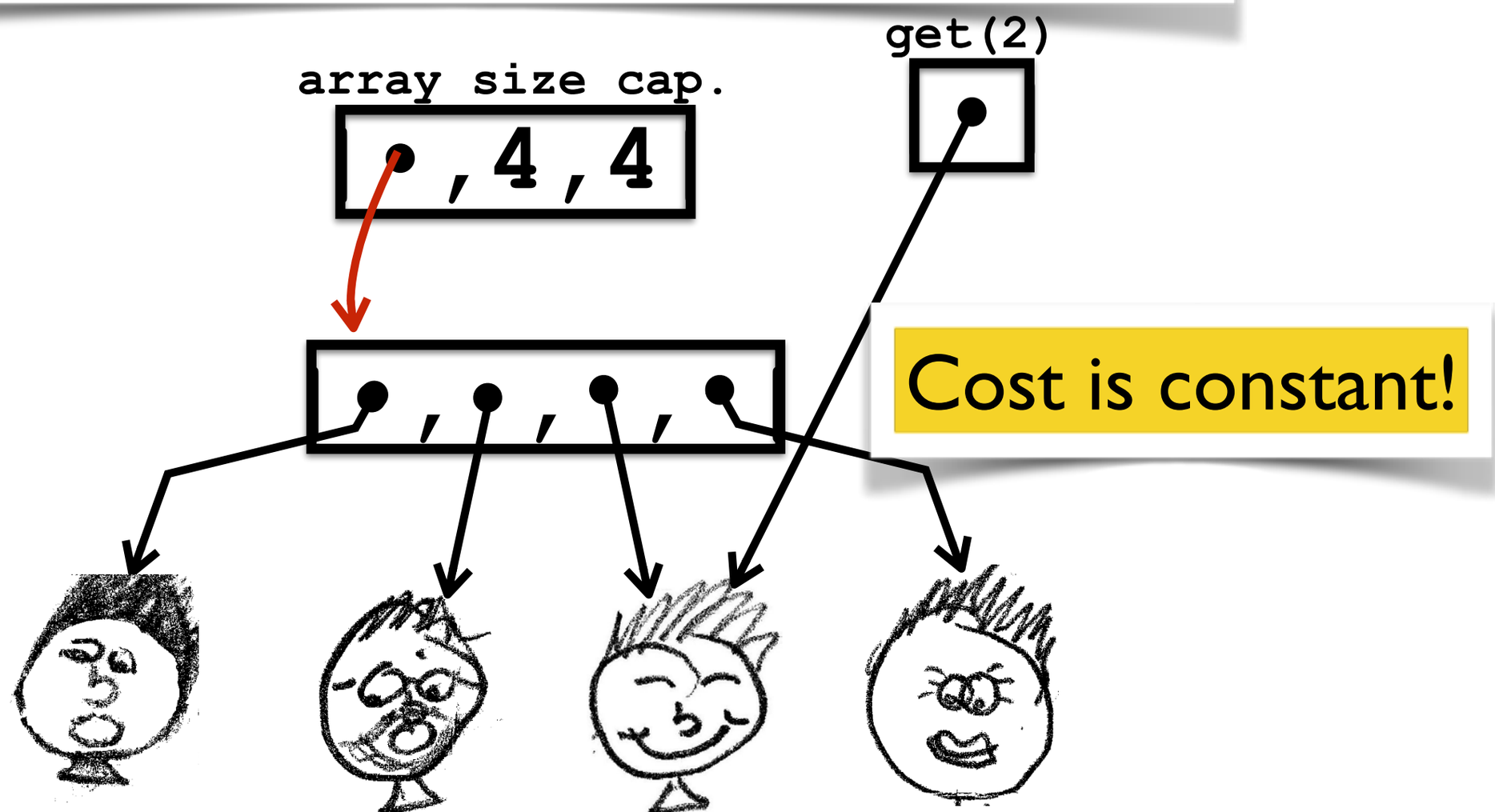

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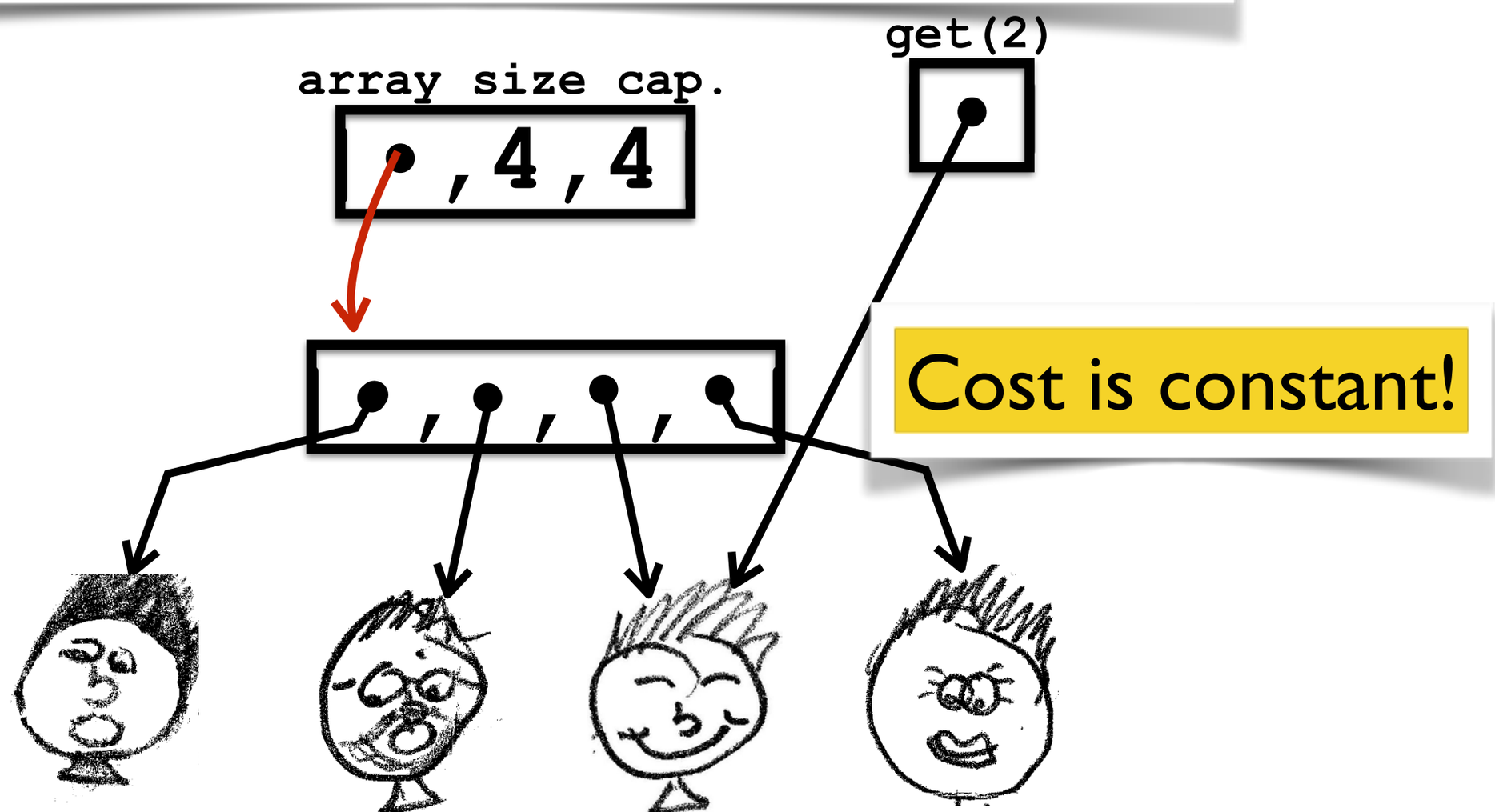

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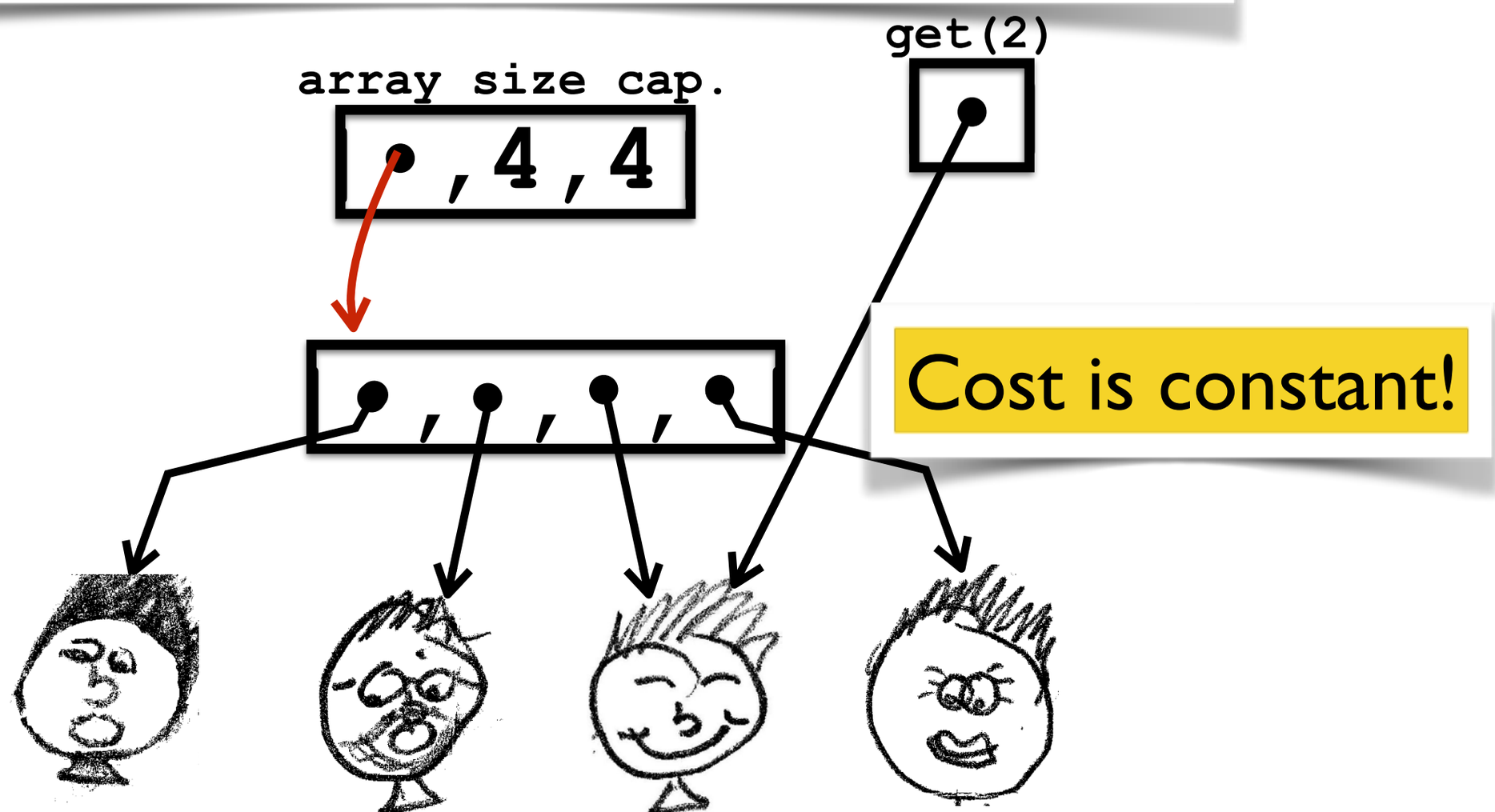

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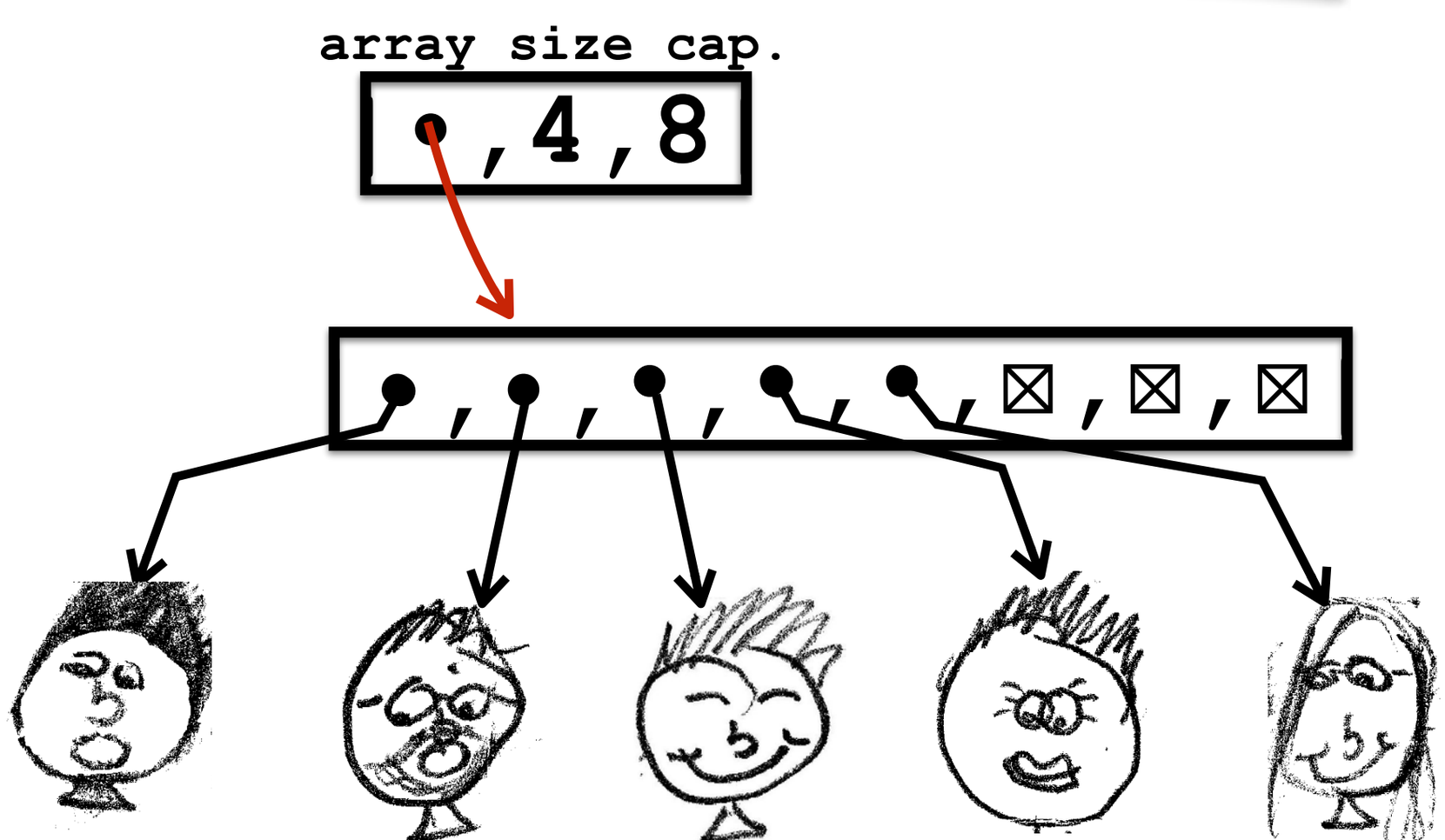

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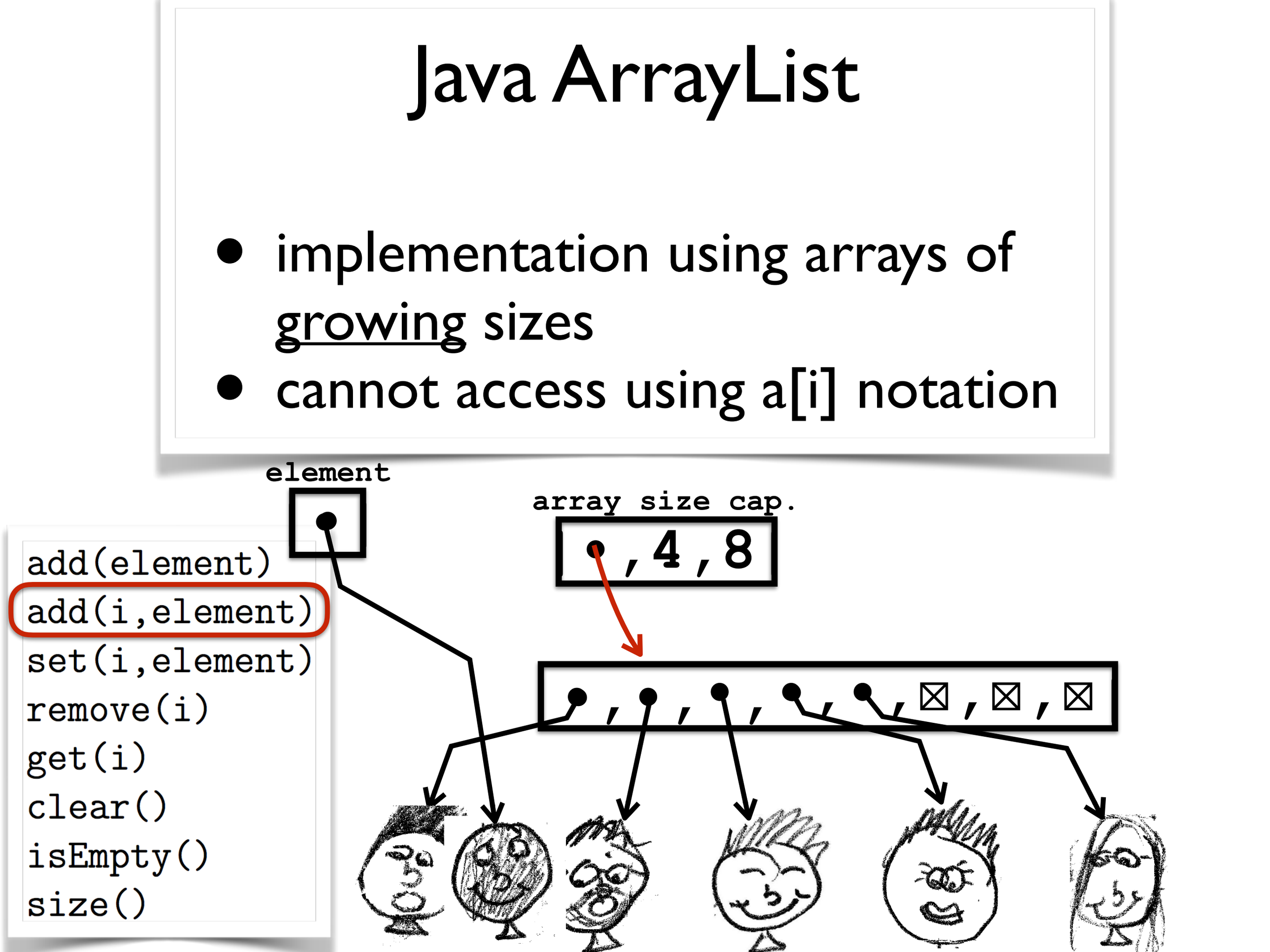

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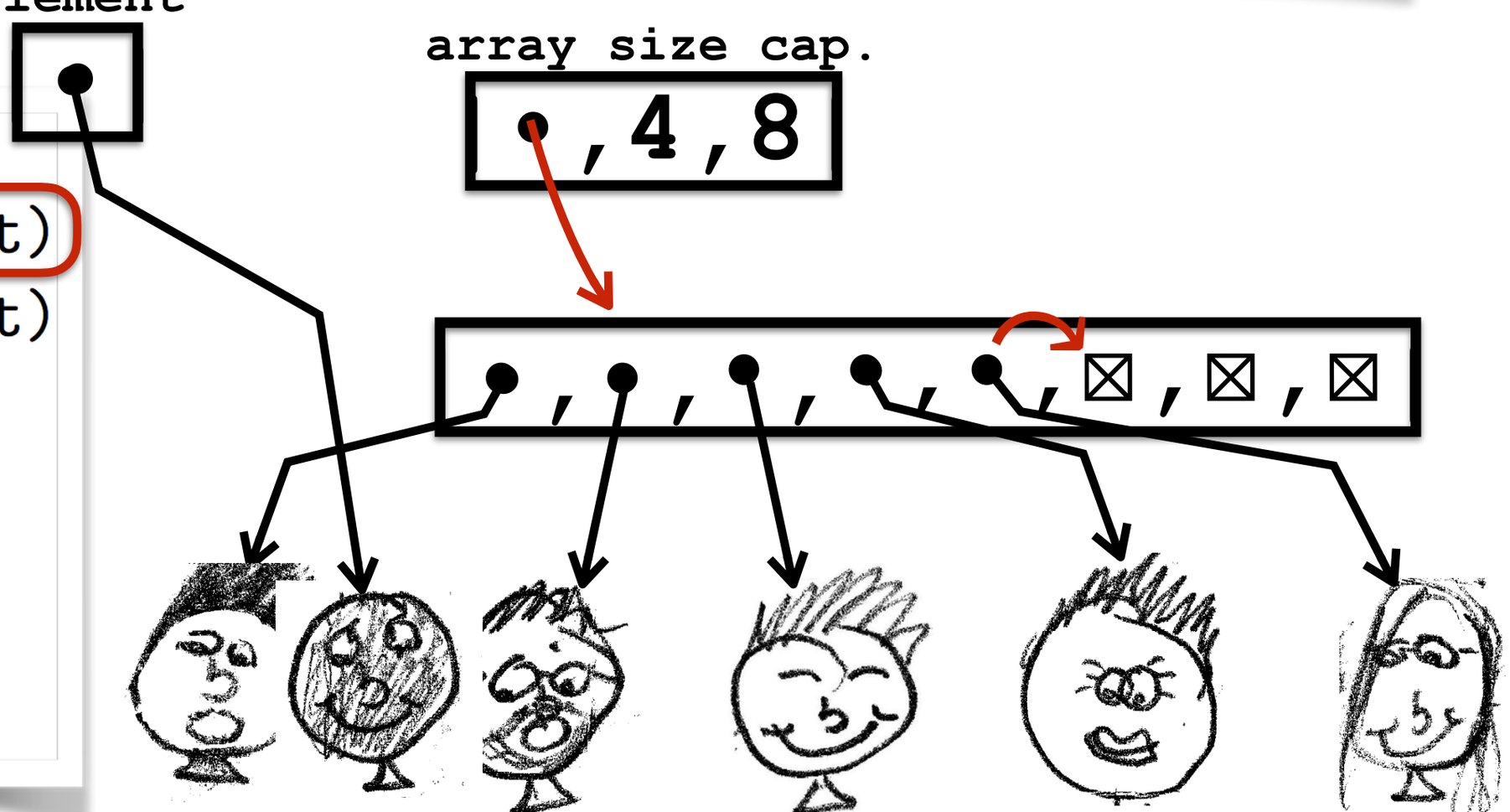

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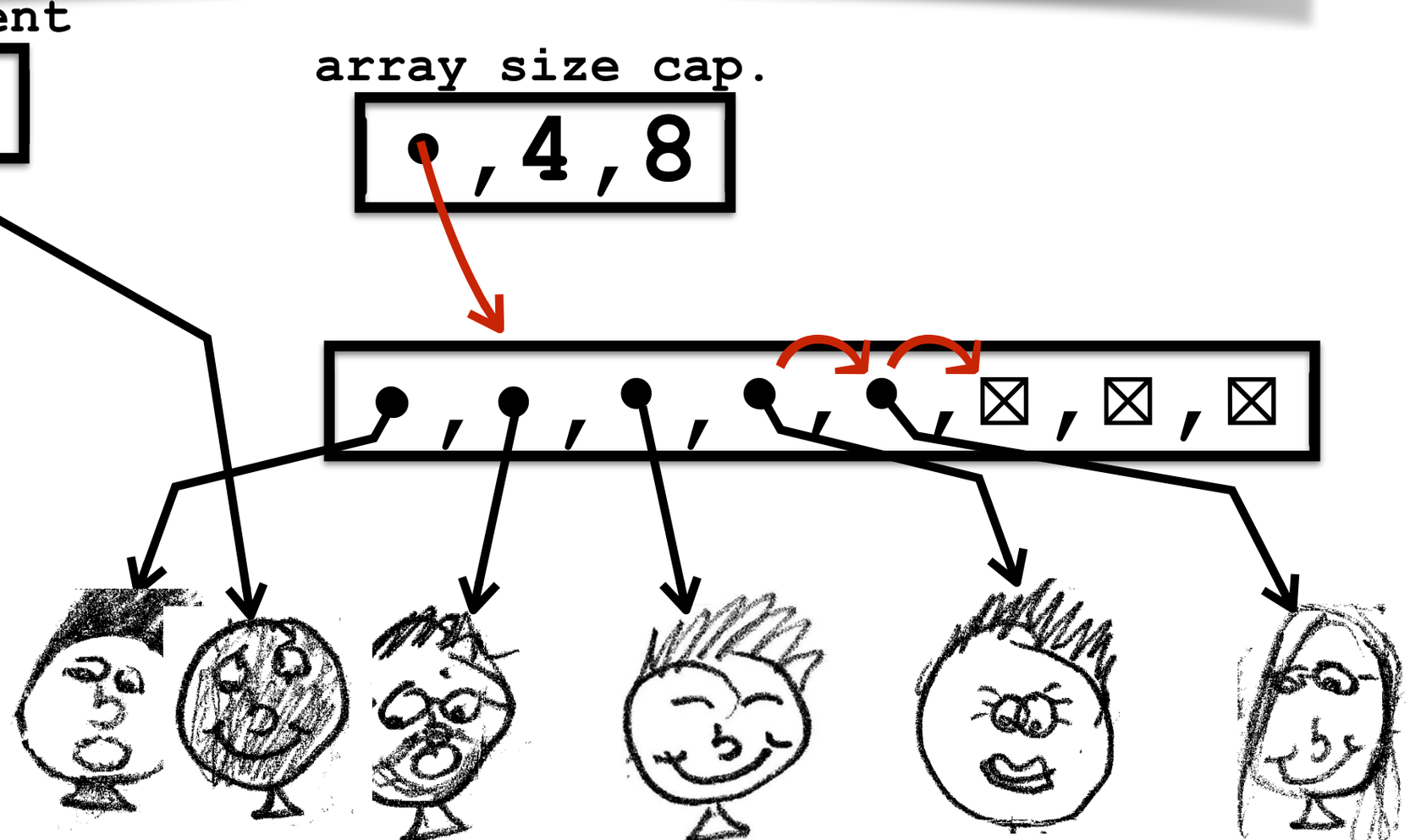

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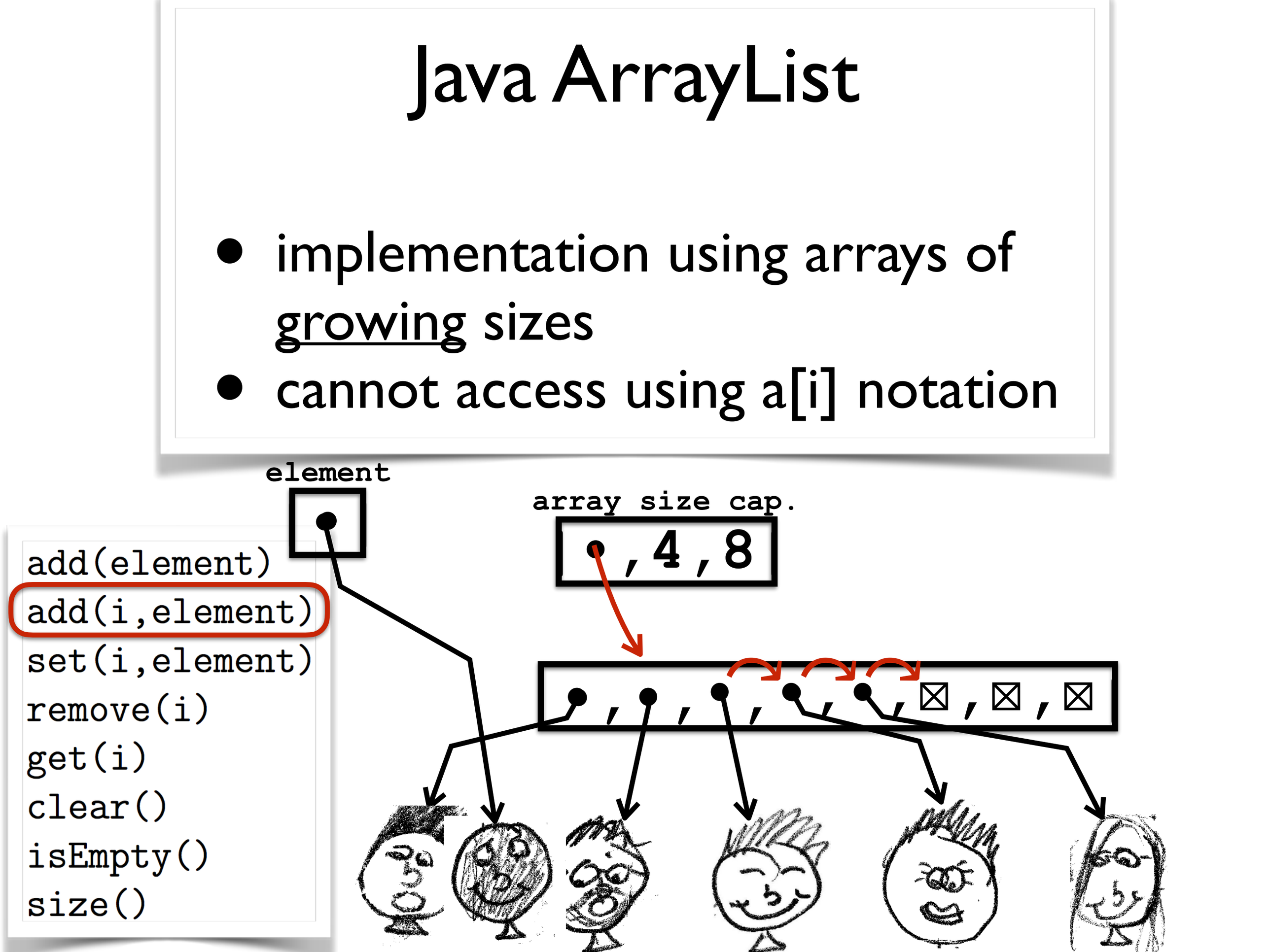

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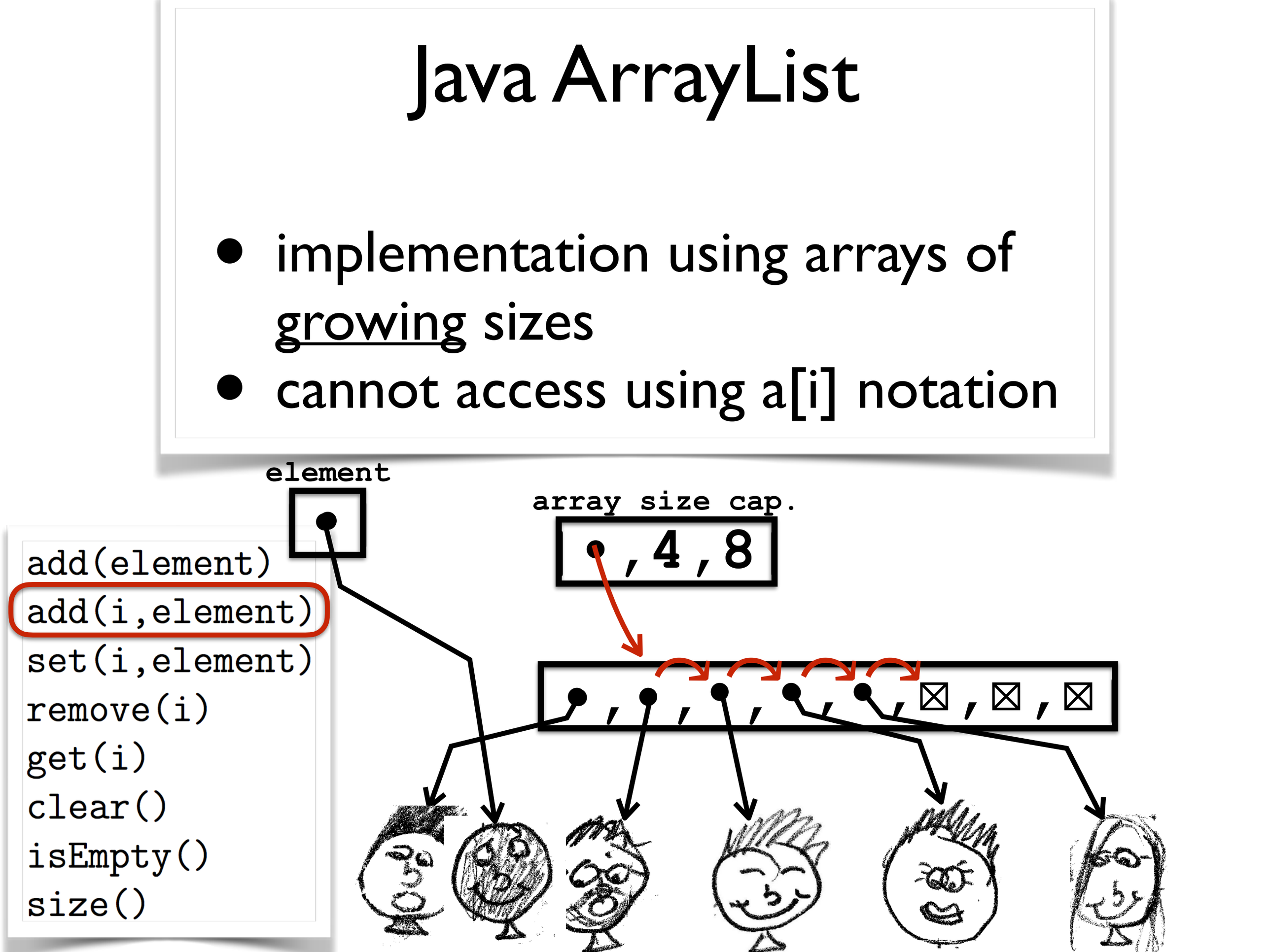

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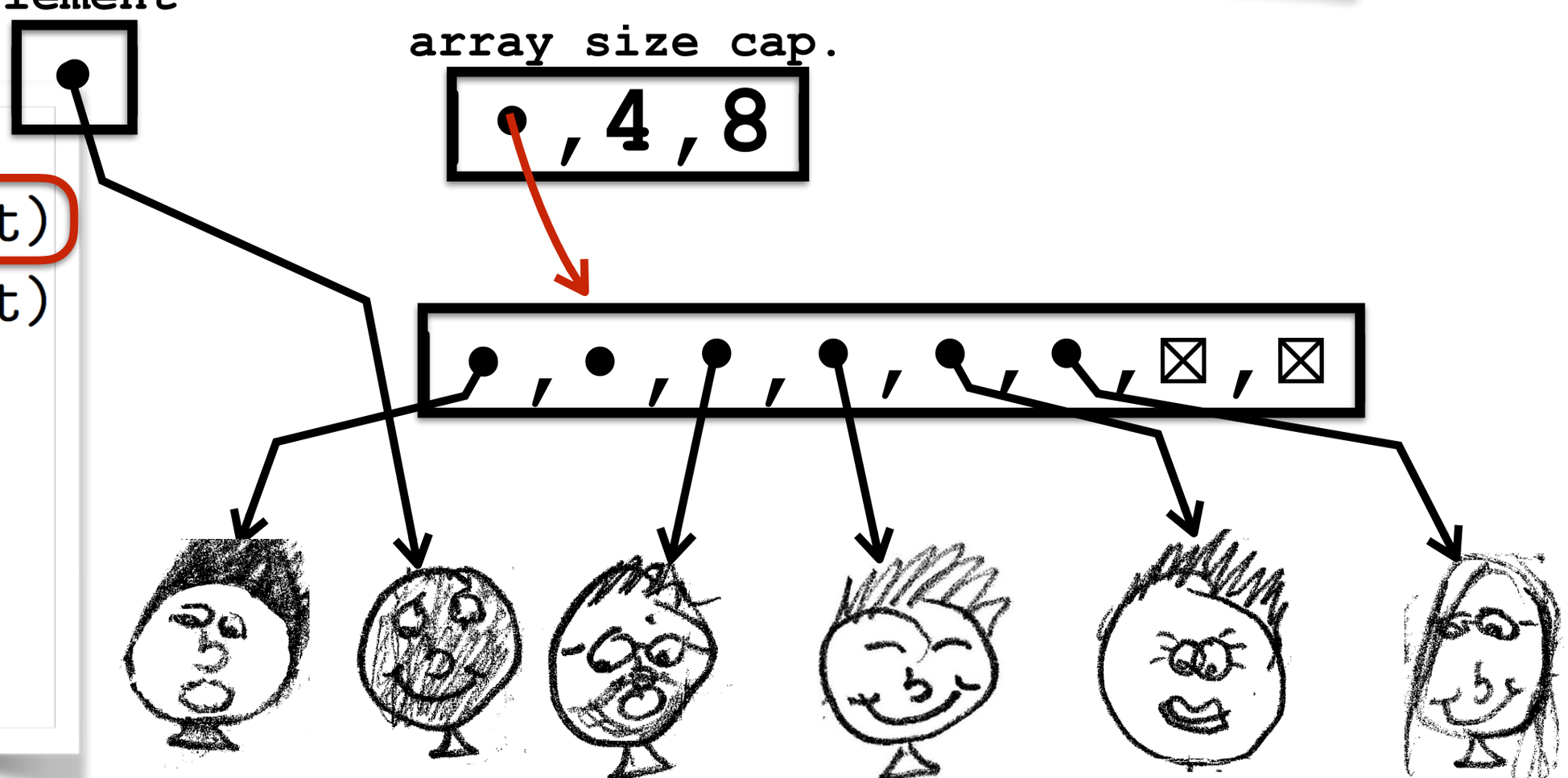

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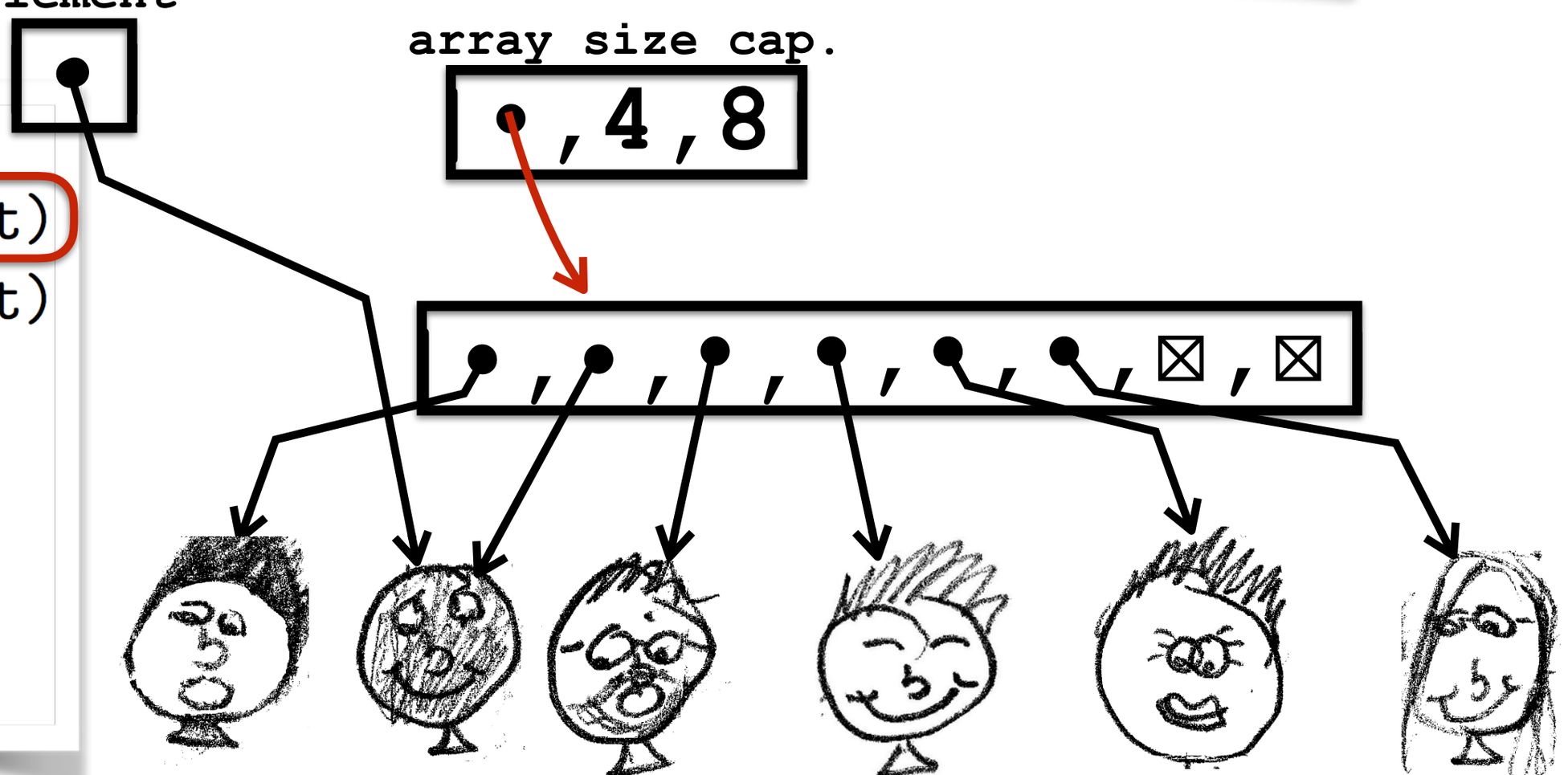

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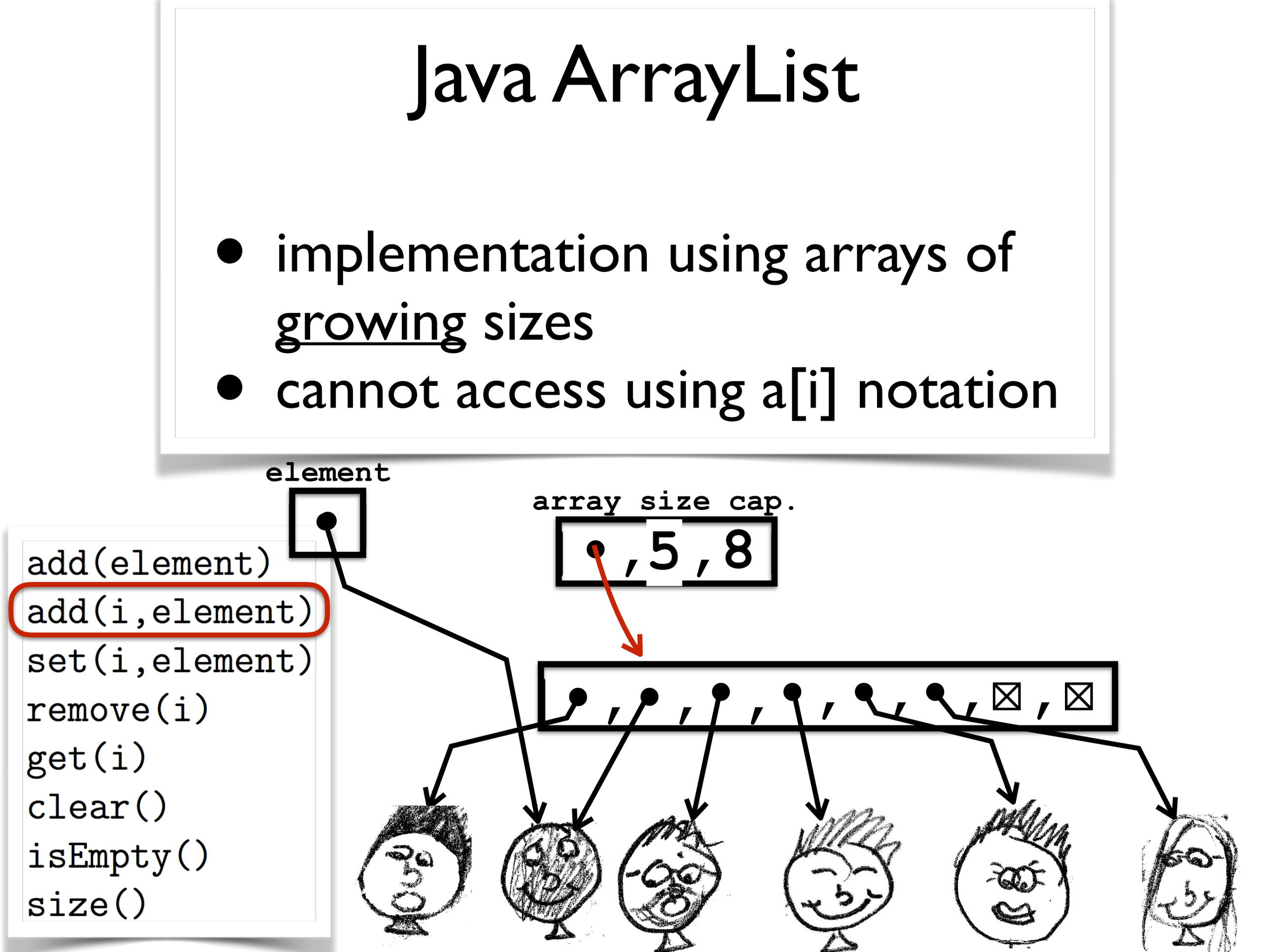

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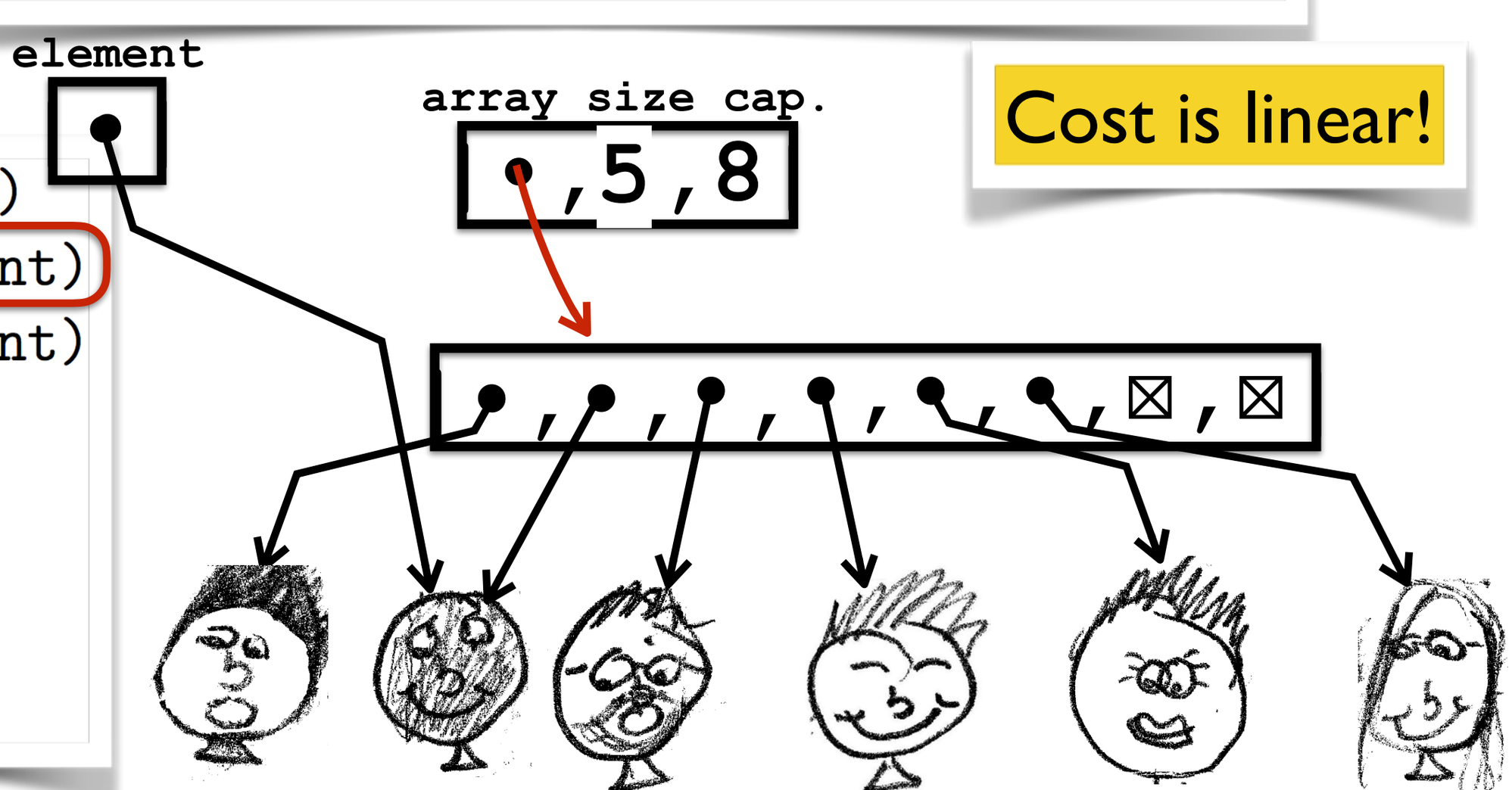

Cost is linear!

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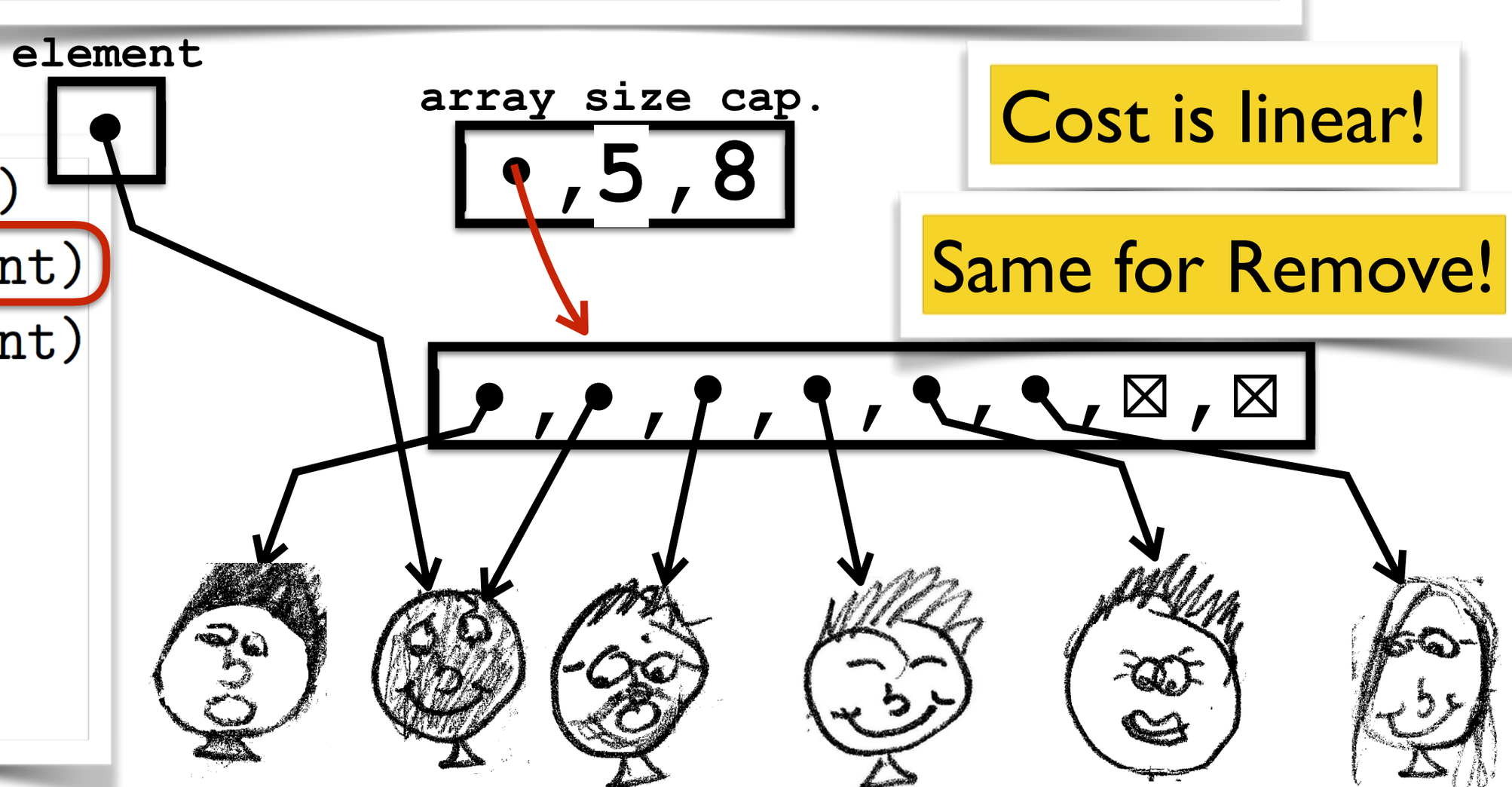

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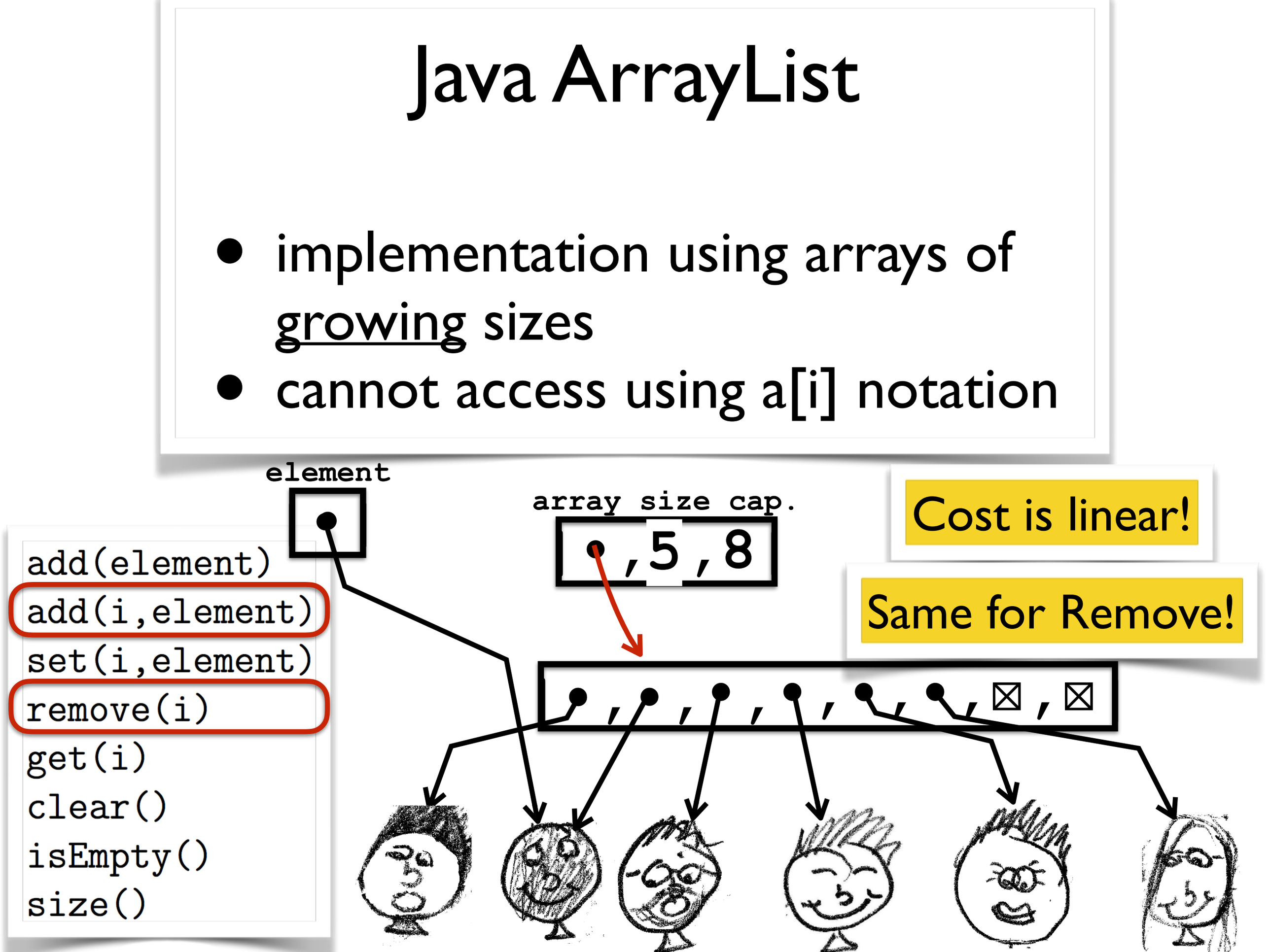

LinkedList vs ArrayList

	LinkedList	ArrayList
add(element)	1	1
add(i,element)	n	n
set(i,element)	n	1
remove(i)	n	n
get(i)	n	1
clear()	1	1
isEmpty()	1	1
size()	1	1

Winter 2016
COMP-250: Introduction to Computer Science

Lecture 6, January 28, 2016