Winter 2016
COMP-250: Introduction to Computer Science

Lecture 5, January 26, 2016

HW I

```
class Number{

   short Base;
   short[] Int;
   short[] NonRep;
   short[] Rep;

};
```

HW1

```
class Number{

//=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+
    public Number convert(Number A, short Base) {
        Number B=new Number();
            B.Base=Base;
            B.Int=A.NonRep; B.NonRep=A.Int; B.Rep=A.NonRep;
        // my code above is just to make sure it compiles and runs
        return B;
        }
//=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

    short Base;
    short[] Int;
    short[] NonRep;
    short[] Rep;
};
```

HW I

```
class Number{

    public void printShortArray(short[] S) {
        for (int i = S.length-1; i>=0; i--) {
          System.out.print(S[i]);
        }
    }

    public void printNumber(Number N) {
        System.out.print("(");
        N.printShortArray(N.Int);
        System.out.print(".");
        N.printShortArray(N.NonRep);
        System.out.print("{");
        N.printShortArray(N.Rep);
        System.out.print("})_");
        System.out.println(N.Base);
    }

    short Base; short[] Int,NonRep,Rep;
};
```

HW I

```
package conv;
public class tester {
    public static void main(String[] args) {

    class Number{
        short Base; short[] Int,NonRep,Rep;
    };

    Number N1=new Number() ;
        N1.Base=10;
        short[] X = {9,1};  N1.Int=X;
        short[] Y = {7,4,2};    N1.NonRep=Y;
        short[] Z = {};     N1.Rep=Z;
        N1.printNumber(N1);

        Number N2=new Number() ;
        short R=2;

        N2=N1.convert(N1, R);
        N2.printNumber(N2);

    }
}
```

Array Algorithms

Sorting

ALGORITHM: INSERTION SORT
INPUT: an array $a[\,]$ with N elements that can be compared $(<, =, >)$
OUTPUT: the array $a[\,]$ containing the same elements, in increasing order

```
for k = 1 to N − 1 do
    tmp ← a[k]
    i ← k
    while (i > 0) & (tmp < a[i − 1]) do
        a[i] ← a[i − 1]
        i ← i − 1
    end while
    a[i] = tmp
end for
```

http://tech-algorithm.com/articles/insertion-sort

Insertion Sort

```
a:[11,13,2,5,21,99,12,51]  tmp:13
a:[11,13,2,5,21,99,12,51]  tmp:13
a:[11,13,2,5,21,99,12,51]  tmp:2
a:[11,13,2,5,21,99,12,51]  tmp:2
a:[2,11,13,5,21,99,12,51]  tmp:2
a:[2,11,13,5,21,99,12,51]  tmp:5
a:[2,11,13,5,21,99,12,51]  tmp:5
a:[2,5,11,13,21,99,12,51]  tmp:5
a:[2,5,11,13,21,99,12,51]  tmp:21
a:[2,5,11,13,21,99,12,51]  tmp:21
a:[2,5,11,13,21,99,12,51]  tmp:99
```

Insertion Sort

```
a:[2,5,11,13,21,99,12,51]  tmp:99
a:[2,5,11,13,21,99,12,51]  tmp:99
a:[2,5,11,13,21,99,12,51]  tmp:12
a:[2,5,11,13,21,99,12,51]  tmp:12
a:[2,5,11,12,13,21,99,51]  tmp:12
a:[2,5,11,12,13,21,99,51]  tmp:51
a:[2,5,11,12,13,21,99,51]  tmp:51
a:[2,5,11,12,13,21,51,99]  tmp:51
a:[2,5,11,12,13,21,51,99]  tmp:51
```

Insertion Sort

a:[2,5,11,13,21,99,12,51] tmp:12

a:[2,5,11,13,21,99,99,51] tmp:12

a:[2,5,11,13,21,21,99,51] tmp:12

a:[2,5,11,13,13,21,99,51] tmp:12

a:[2,5,11,12,13,21,99,51] tmp:12

a:[2,5,11,12,13,21,99,51] tmp:51

Analysis of Insertion Sort

ALGORITHM: INSERTION SORT
INPUT: an array $a[\,]$ with N elements that can be compared $(<, =, >)$
OUTPUT: the array $a[\,]$ containing the same elements, in increasing order

```
for k = 1 to N − 1 do                                          } linear~quadratic
    tmp ← a[k]                                                 }
    i ← k                                                      } cst
    while (i > 0) & (tmp < a[i − 1]) do                        } cst~linear
        a[i] ← a[i − 1]                                        }
        i ← i − 1                                              }
    end while
    a[i] = tmp                                                 } cst
end for
```

Analysis of Insertion Sort

ALGORITHM: INSERTION SORT
INPUT: an array $a[\,]$ with N elements that can be compared $(<, =, >)$
OUTPUT: the array $a[\,]$ containing the same elements, in increasing order

```
for k = 1 to N − 1 do                                   } linear
    tmp ← a[k]                                          } cst
    i ← k                                               } cst
    while (i > 0) & (tmp < a[i − 1]) do                 } cst
        a[i] ← a[i − 1]                                 } cst
        i ← i − 1                                       } cst
    end while                                           } cst
    a[i] = tmp                                          } cst
end for
```

$$\text{Time}(N) \geq c_1 + c_2 \times N$$

Analysis of Insertion Sort

ALGORITHM: INSERTION SORT
INPUT: an array $a[\,]$ with N elements that can be compared $(<, =, >)$
OUTPUT: the array $a[\,]$ containing the same elements, in increasing order

```
for k = 1 to N − 1 do
    tmp ← a[k]          } cst
    i ← k               } cst
    while (i > 0) & (tmp < a[i − 1]) do
        a[i] ← a[i − 1]     } cst
        i ← i − 1           } cst
    end while
    a[i] = tmp          } cst
end for
```

linear

quadratic

$$\text{Time}(N) \leq c_1 + c_2 \times N + c_3 \times N^2$$

Analysis of Algorithms

Best Case

`Time(N)` **`is`** $\boldsymbol{\Omega}$`(N)`

Worst Case

`Time(N)` **`is`** $O(N^2)$

(Singly) Linked List

Linked Lists

List = ordered set of elements.

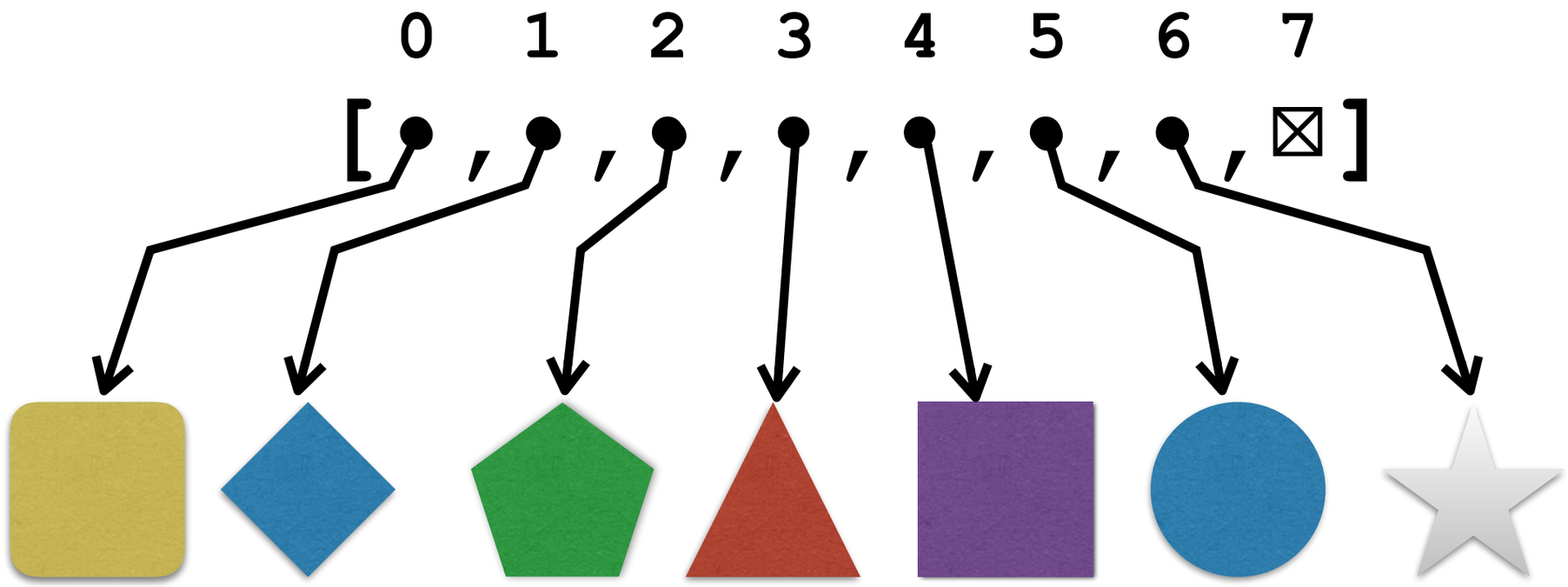
$(a_0, a_1, \ldots, a_{Size-1})$

Size = number of elements.

Array of integers:

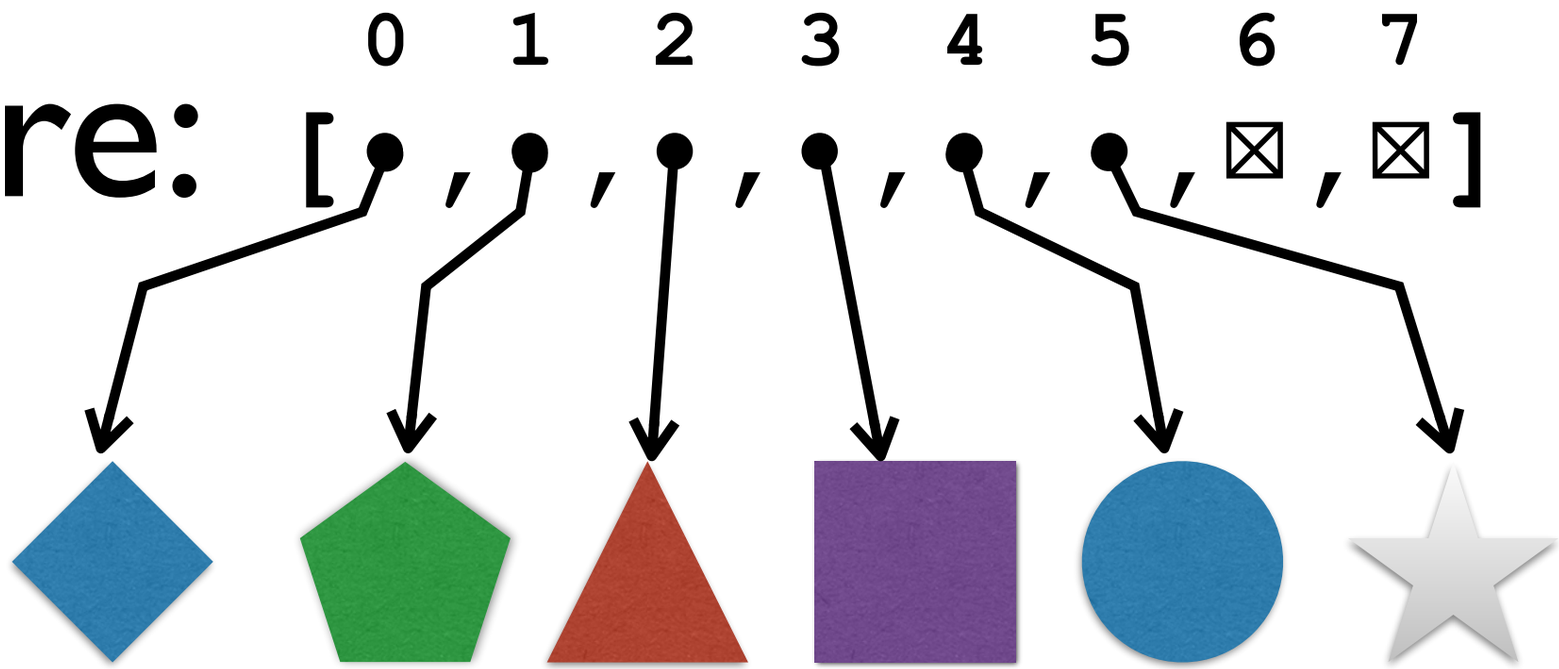
```
  0  1  2  3  4  5  6  7
[5,2,9,3,3,1,7,0]
```

Array of shapes:

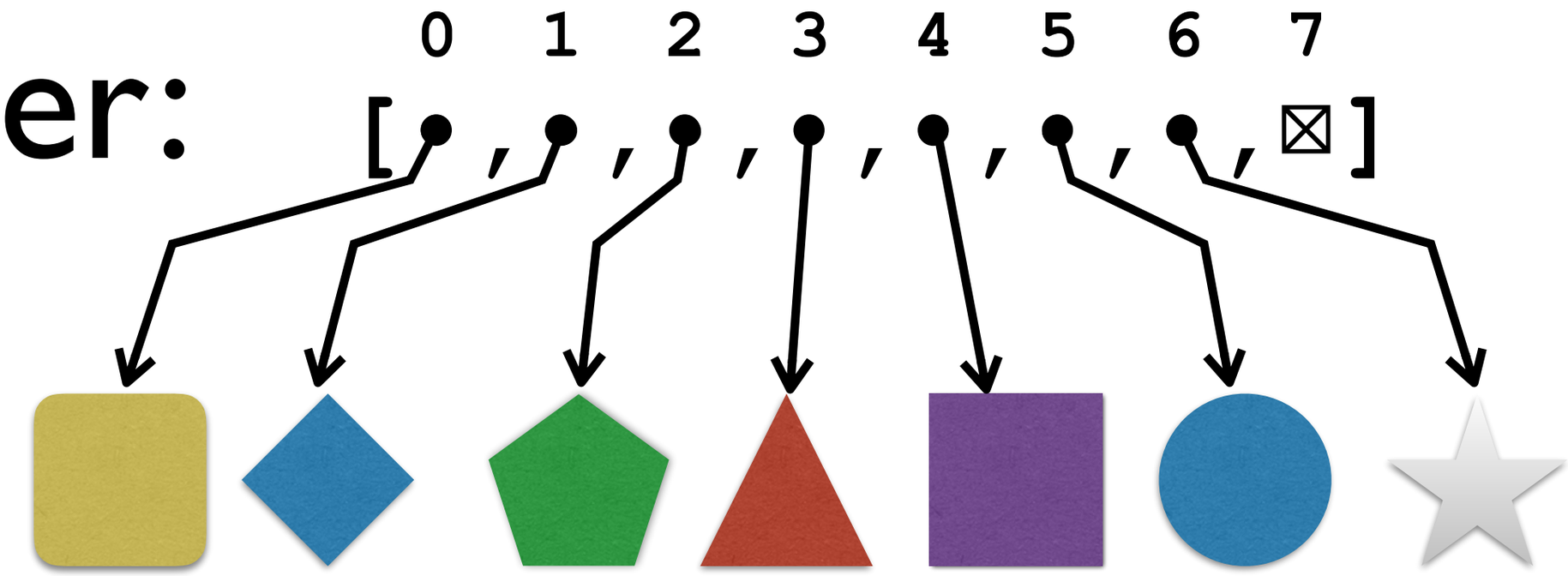


Adding an element to List

Before:



After:



Adding element to Front

```
//   add new element to front of the list
//   assuming that there is room left in the array
//
     for (i = size; i > 0; i--)
         a[i] = a[i-1]
     a[0] = new element
     size = size + 1
```

Removing element at Front

```
//   remove the element at front of the list
//
for (i = 1; i < size-1; i++)
    a[i-1] = a[i]
a[size-1] = null
size = size - 1
```

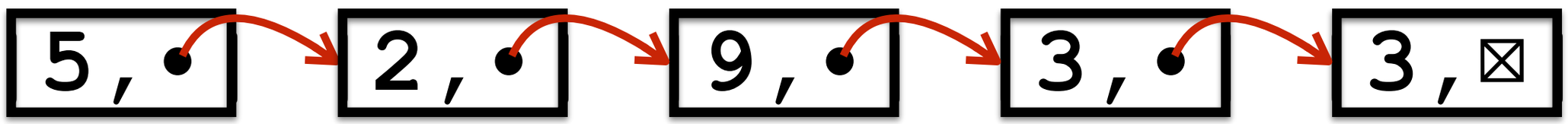
Adding/Removing at End

```
//   add new last element to the list
//   assuming that there is room left in the array
//
     a[size] = new element
     size = size + 1



//   remove the last element from the list
//
     a[size-1] = null
     size = size - 1
```

Array of integers:

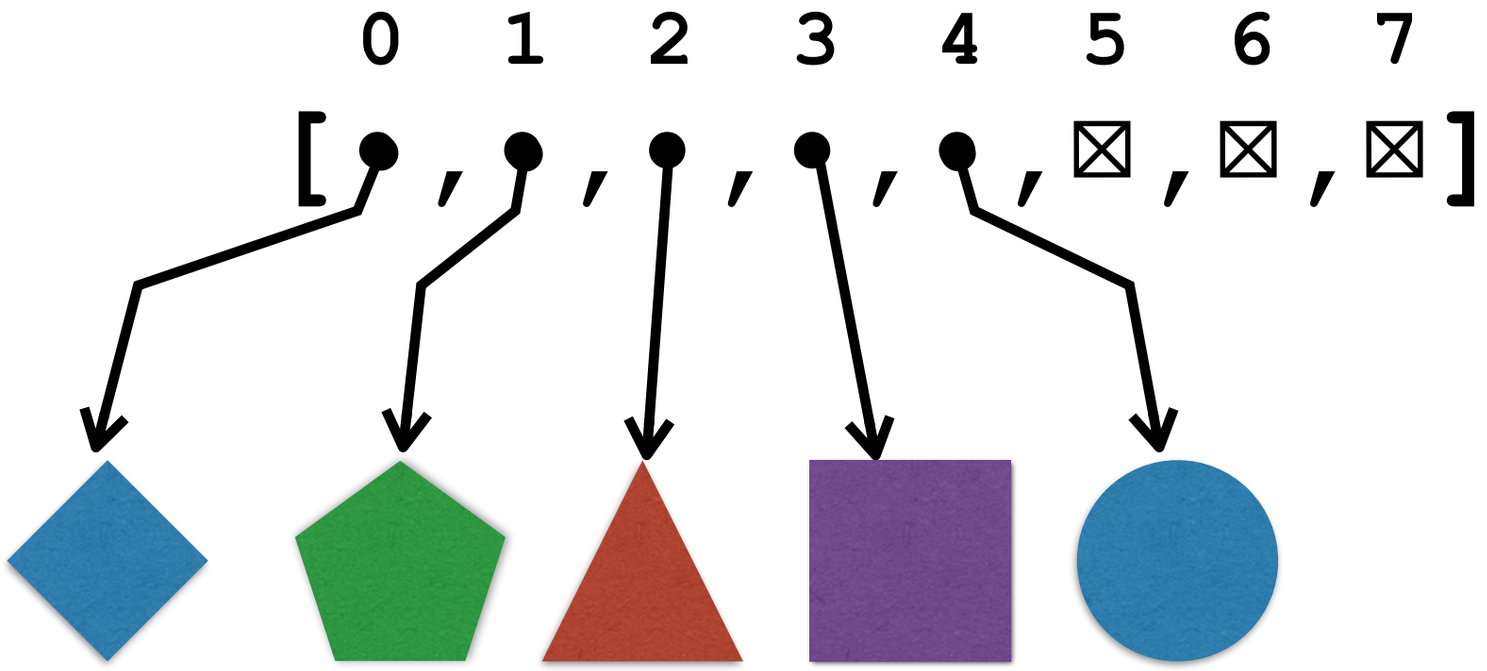
```
  0  1  2  3  4  5  6  7
[5,2,9,3,3,0,0,0]
```

Linked list of integers:

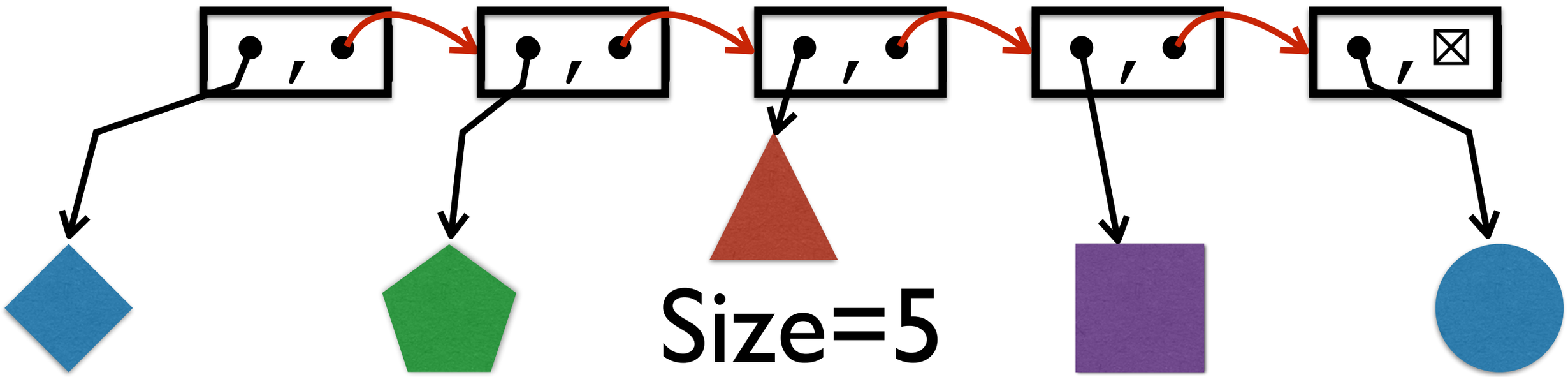


Size=5

Array of shapes:

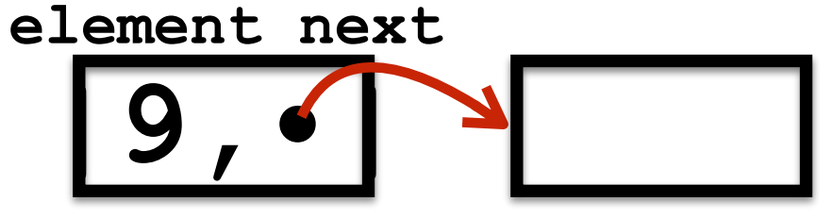


Linked list of shapes:



(Singly) Linked List Node

```
class  SNode{
    Type                element;
    SNode               next;
}
```



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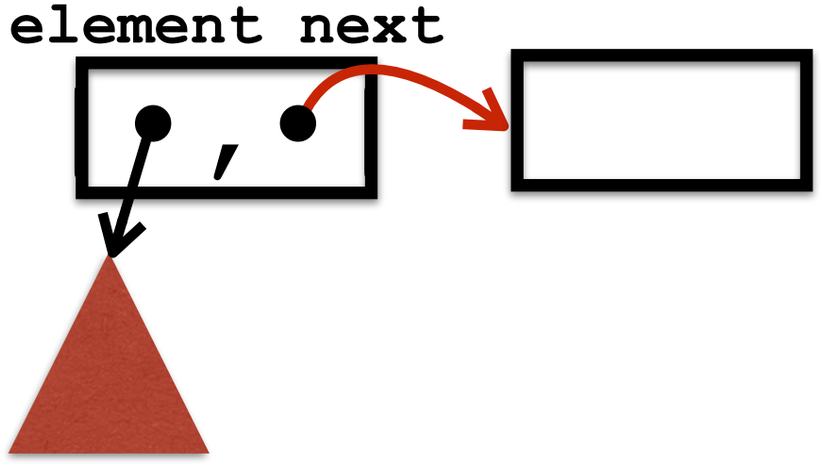
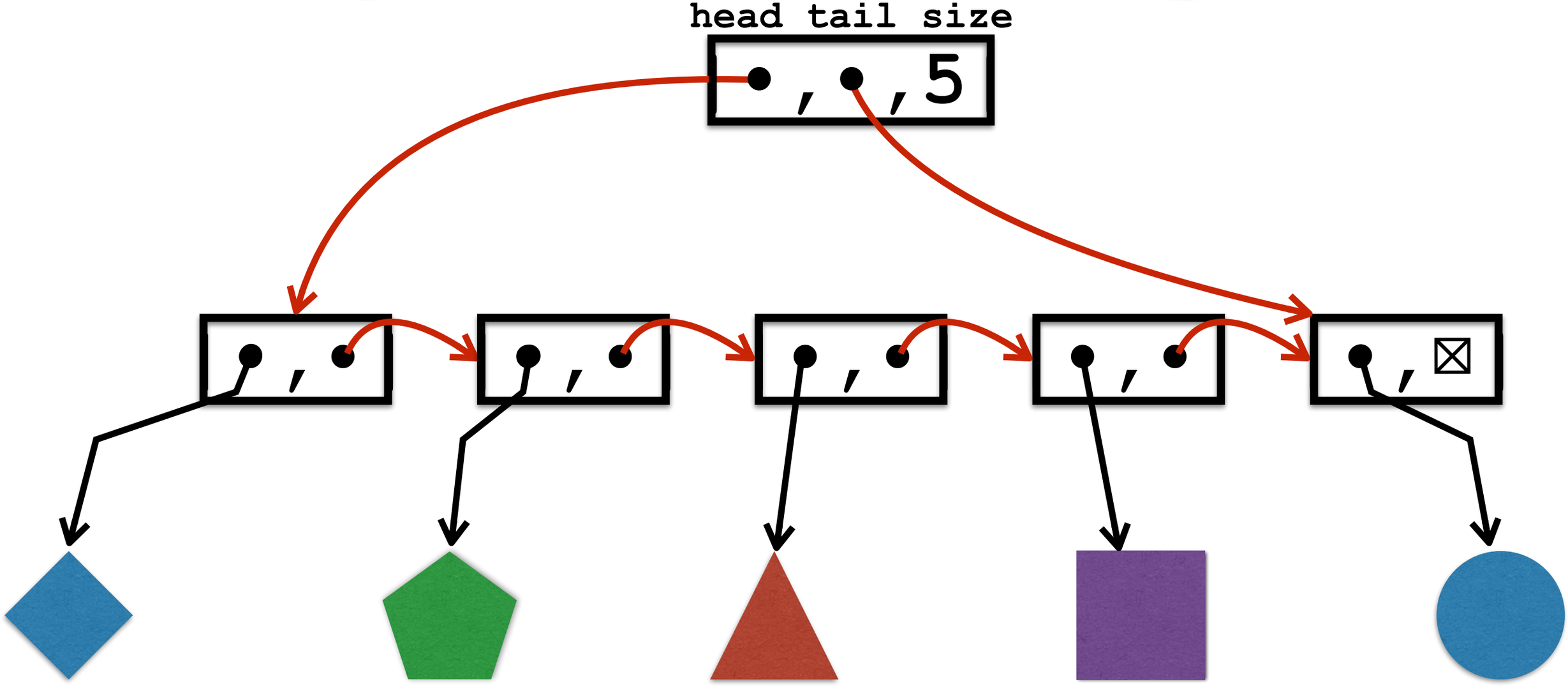
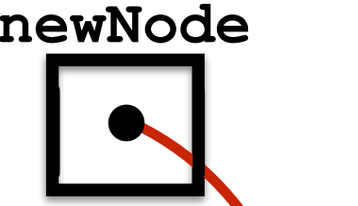


```
class  SLinkedList{
    SNode                head;
    SNode                tail;
    integer              size;
}
```

```
class  SLinkedList{
    SNode              head;
    SNode              tail;
    integer            size;
}
```



```
addFirst( newNode ){
    newNode.next = head;
    head = newNode;
    size = size + 1;
}
```



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    newNode.next = head;
    head = newNode;
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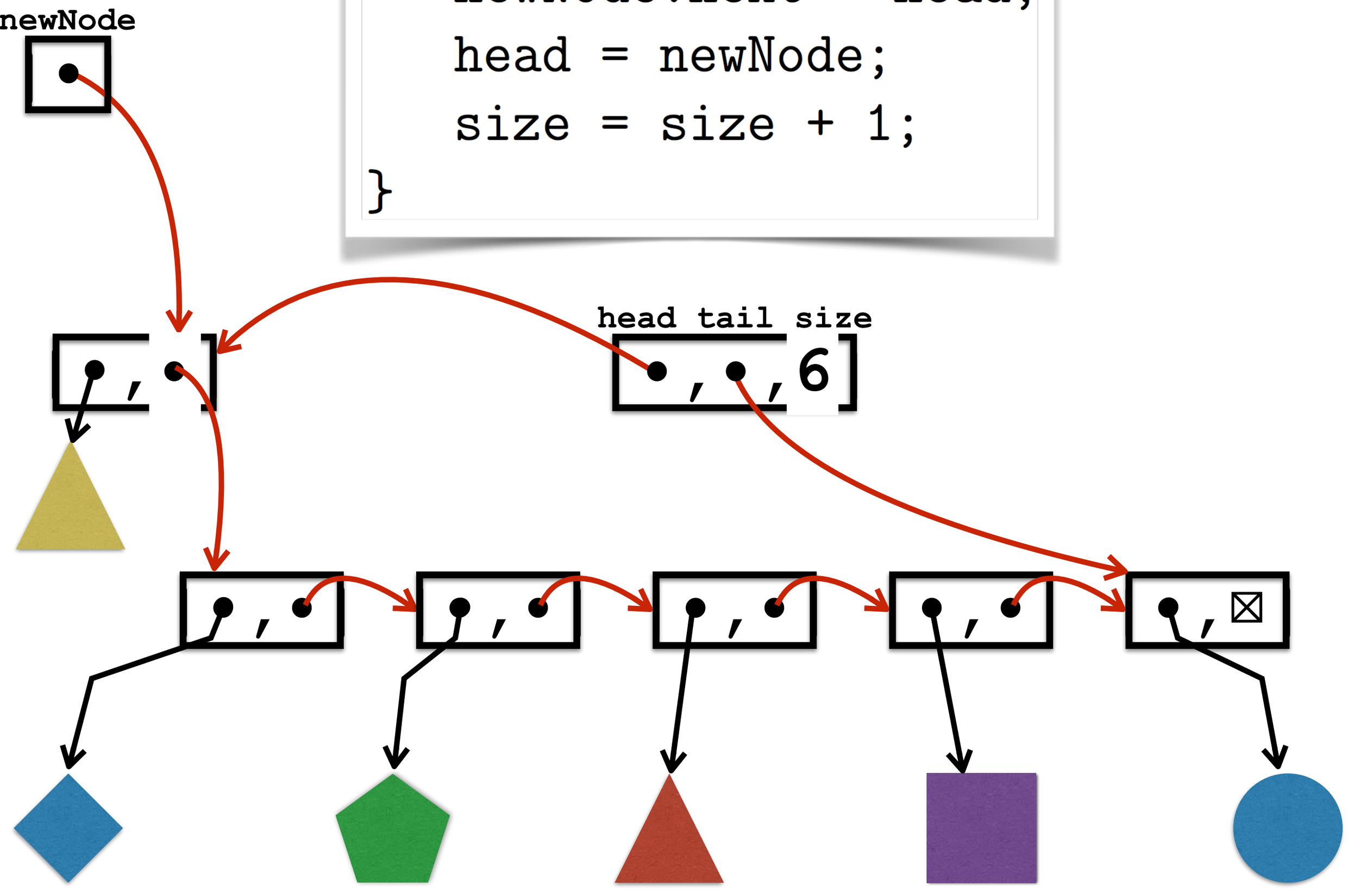
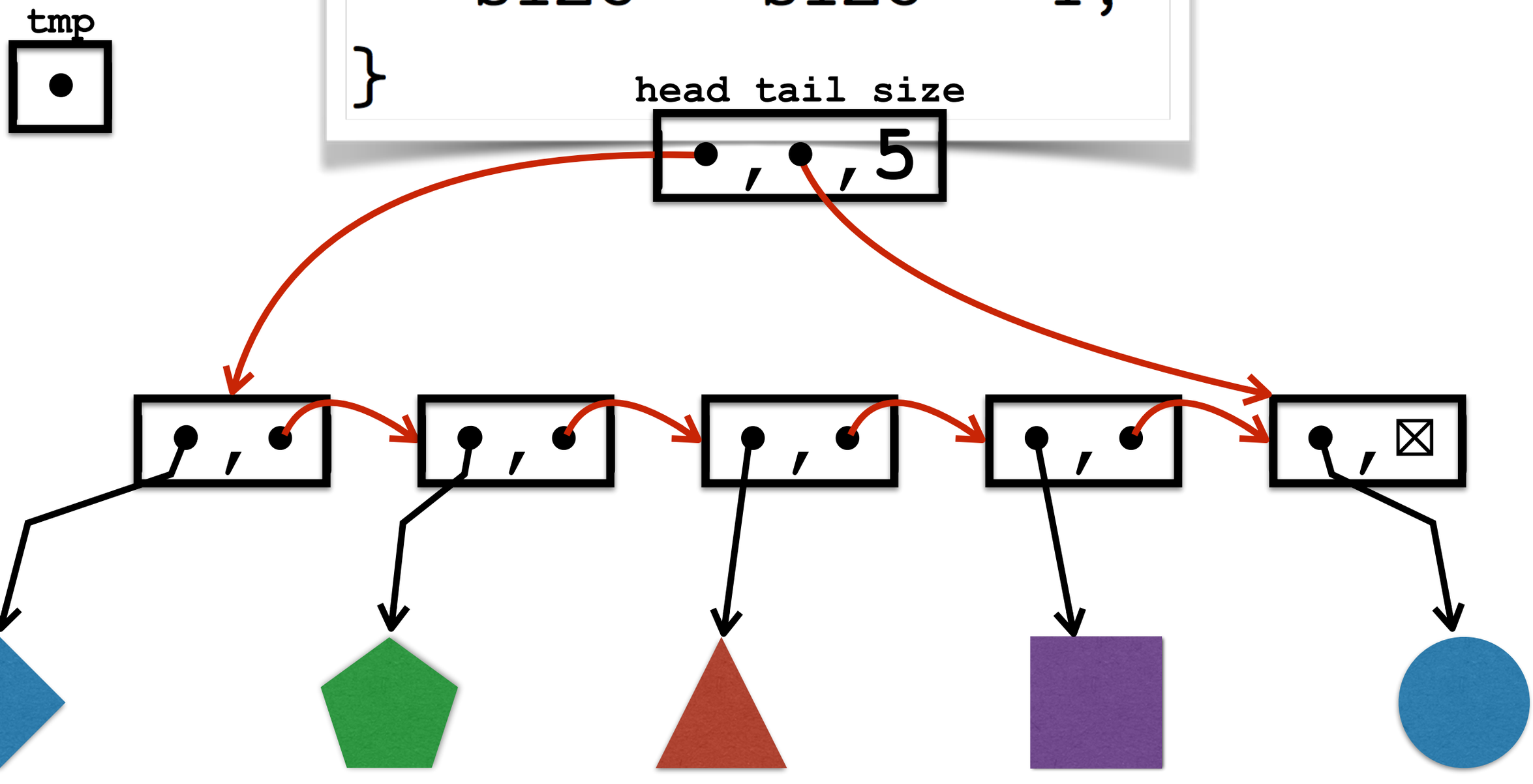
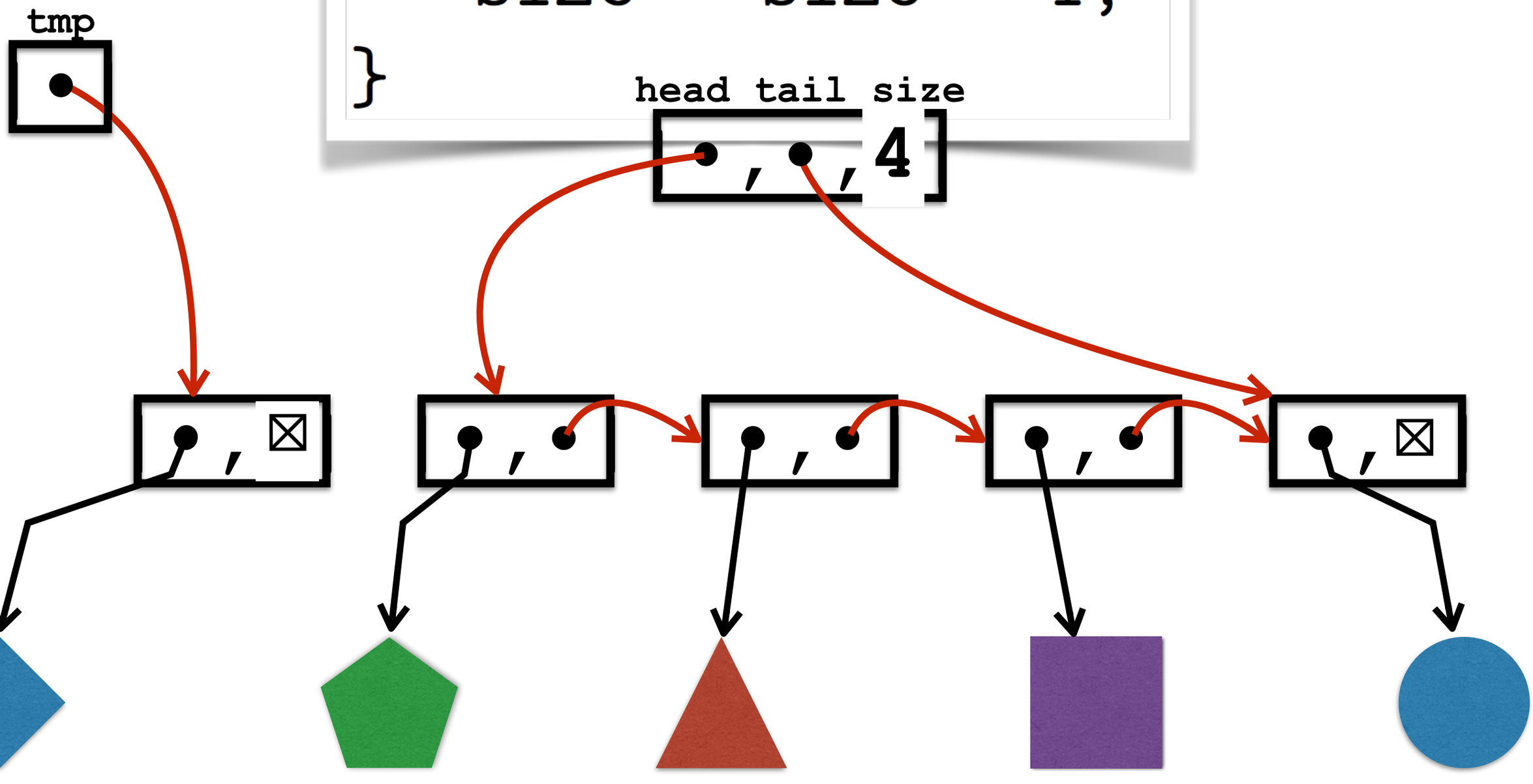
}
```



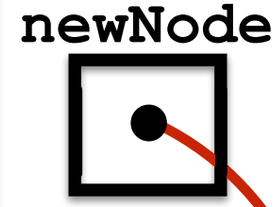
```
removeFirst(){
    tmp = head;
    head = head.next;
    tmp.next = null;
    size = size - 1;
}
```

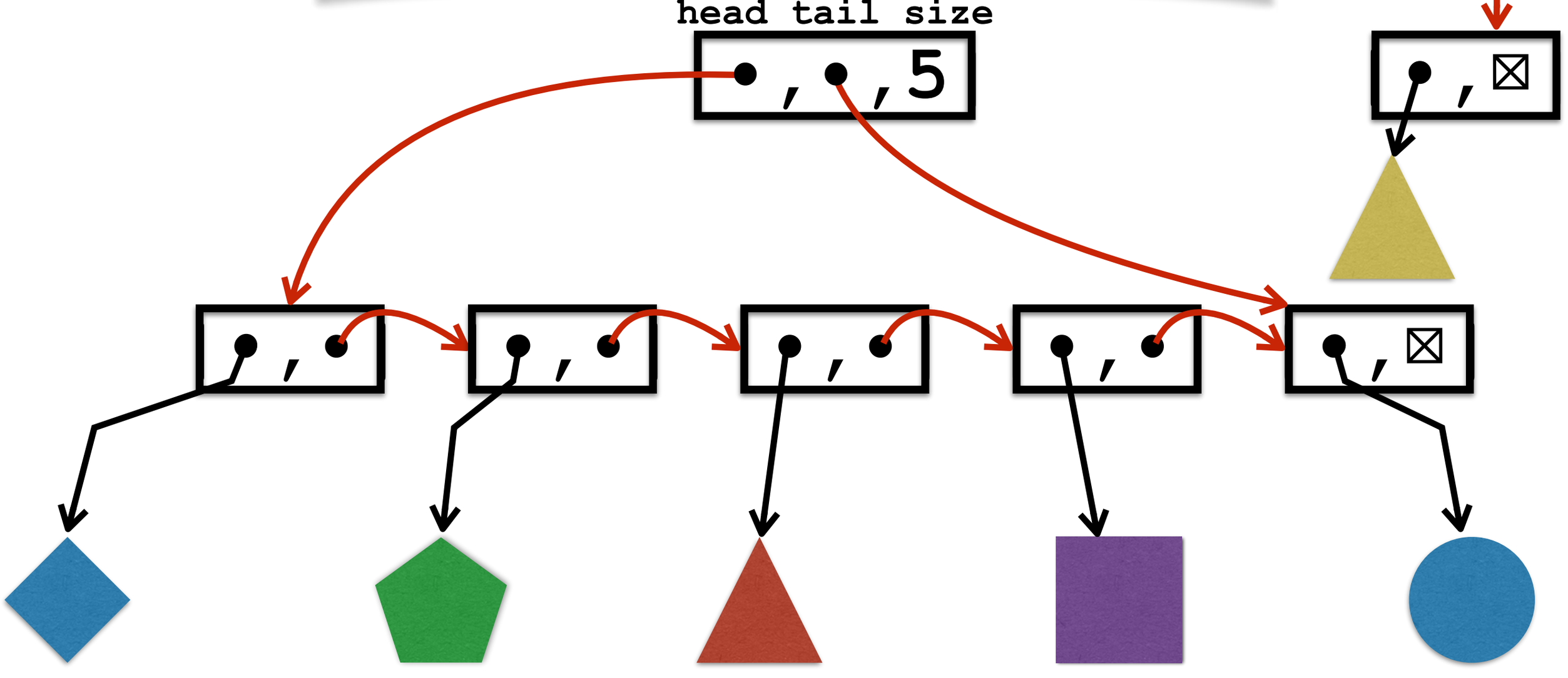


```
removeFirst(){
    tmp = head;
    head = head.next;
    tmp.next = null;
    size = size - 1;
}
```

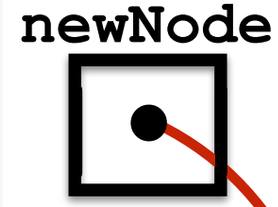


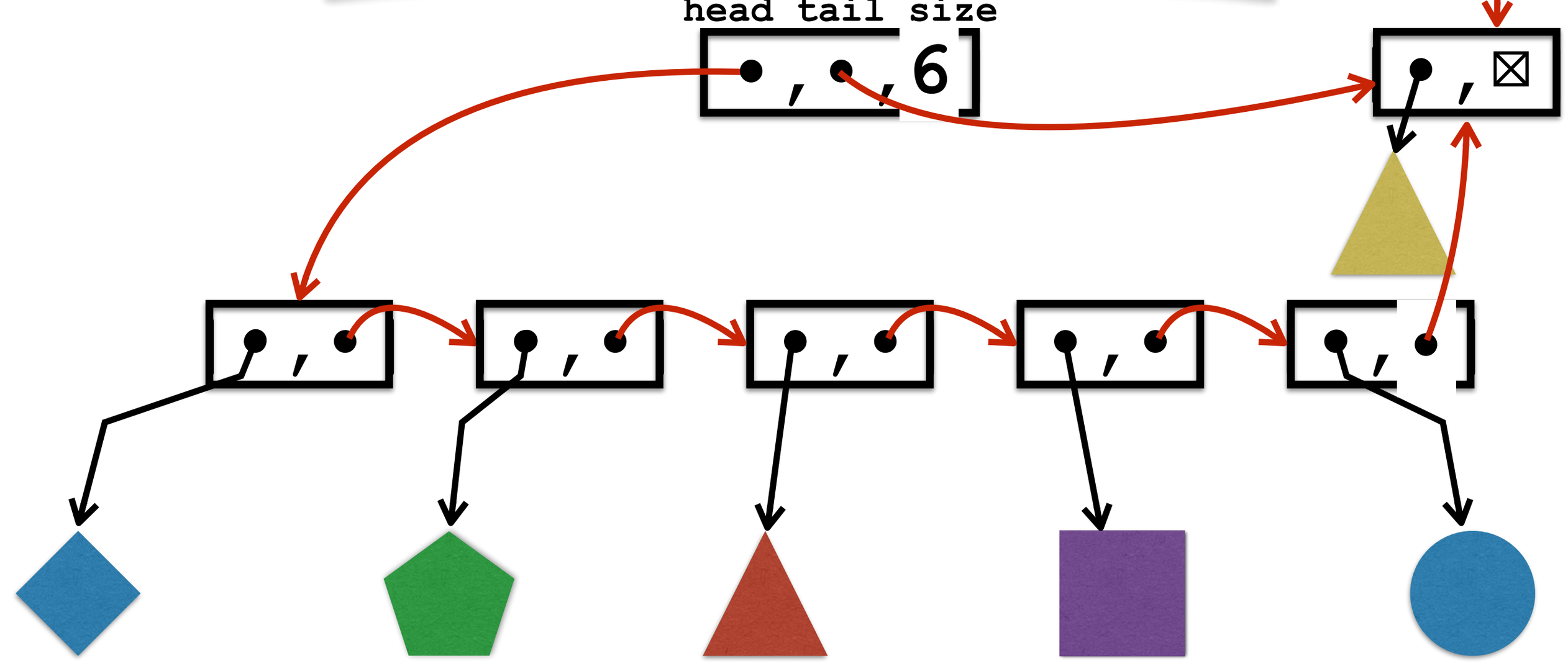
```
addLast( newNode ){
    tail.next = newNode;
    tail = tail.next;
    size = size + 1;
}
```





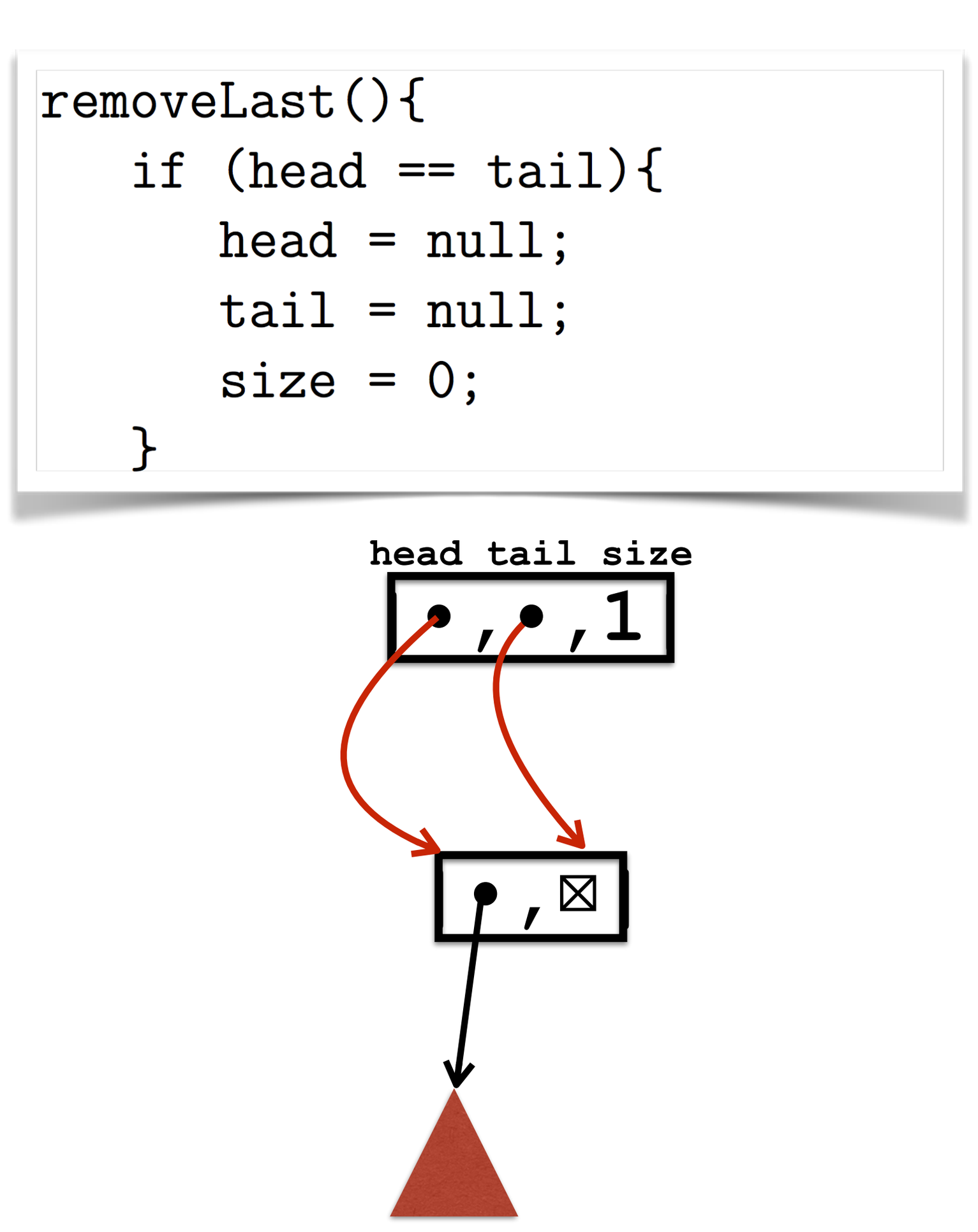
```
addLast( newNode ){
    tail.next = newNode;
    tail = tail.next;
    size = size + 1;
}
```





```
removeLast(){
    if (head == tail){
        head = null;
        tail = null;
        size = 0;
    }
    else{
      tmp = head;
      while (tmp.next != tail){
          tmp = tmp.next;
      }
      tmp.next = null;
      tail = tmp;
      size = size - 1;
    }
}
```

```
removeLast(){
    if (head == tail){
        head = null;
        tail = null;
        size = 0;
    }
```



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removeLast(){
    if (head == tail){
        head = null;
        tail = null;
        size = 0;
    }
```
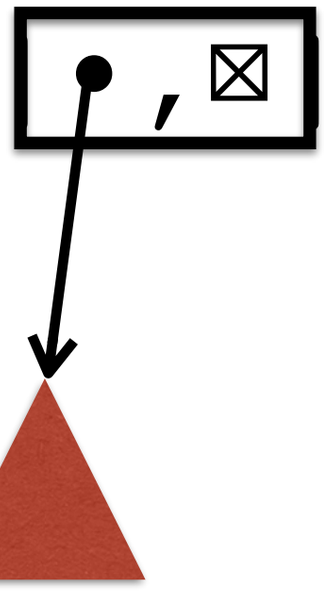
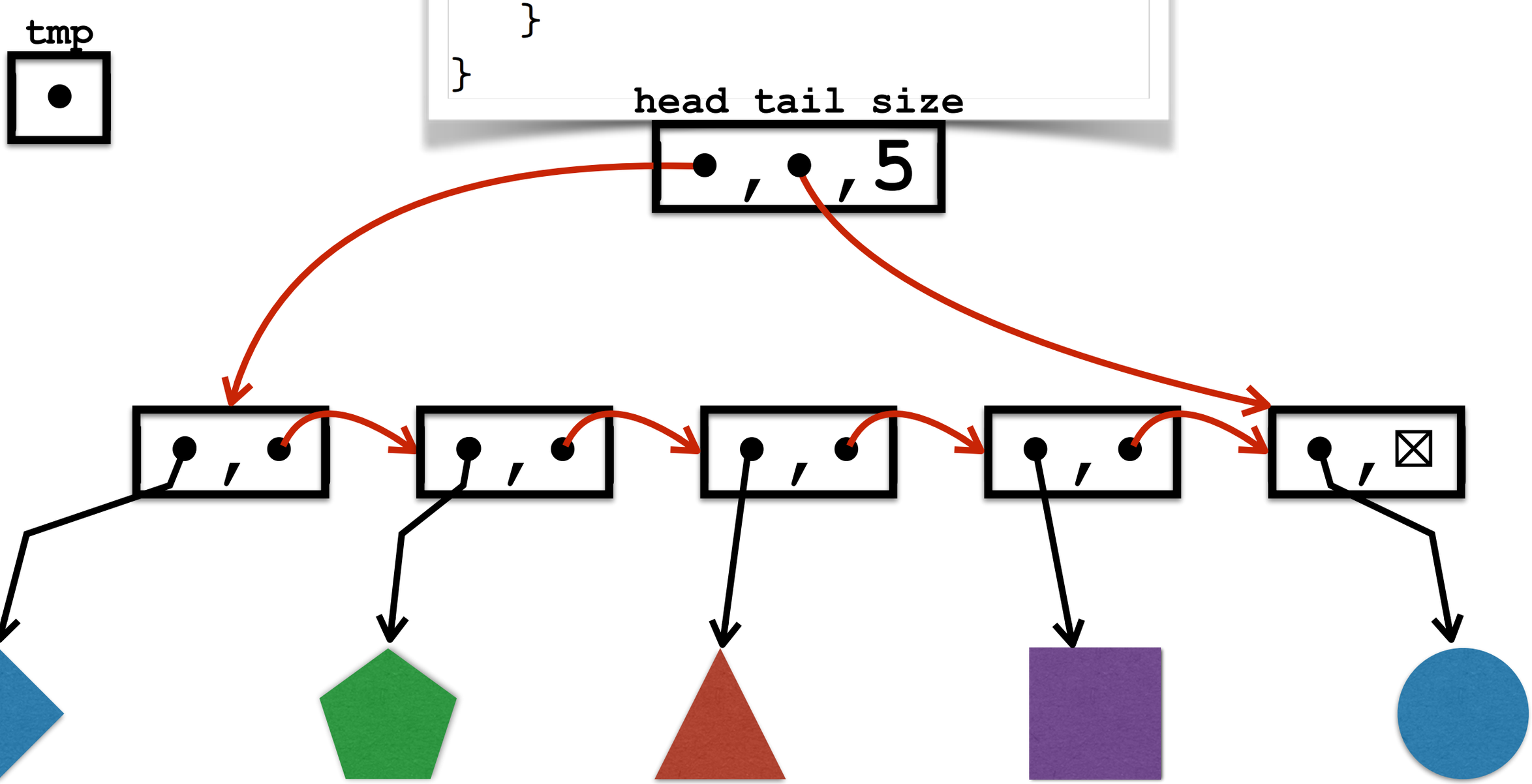



```
    else{
      tmp = head;
      while (tmp.next != tail){
         tmp = tmp.next;
      }
      tmp.next = null;
      tail = tmp;
      size = size - 1;
    }
}
```



```
    else{
      tmp = head;
      while (tmp.next != tail){
         tmp = tmp.next;
      }
      tmp.next = null;
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      size = size - 1;
    }
}
```

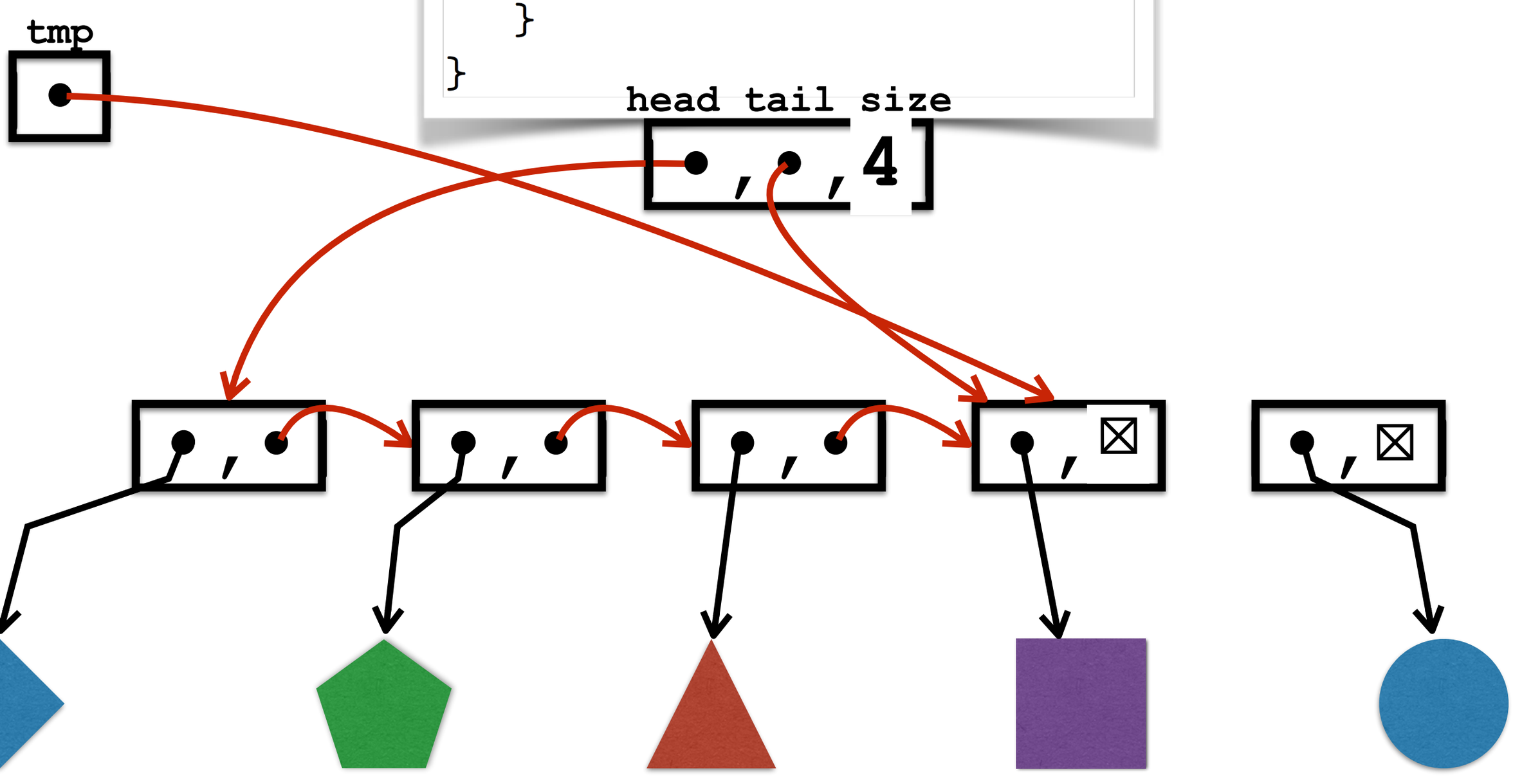

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