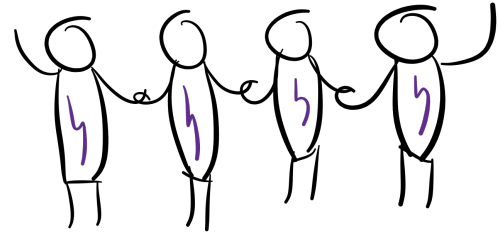


# CSE 143

## Computer Programming II

## List Nodes



### Today's Goals

1

- Get familiar with the idea of “references” (things that point to objects)
- Define and explore **ListNode**
- Learn about null
- Practice modifying linked lists
- Get familiar with matching up code and pictures of linked lists

### Memory

2

Consider the following two documents in a text editor:

- A normal book
- A “choose your own adventure” book

Which tasks are easy/hard in each type of book?

- Find the last page
- Add a new page in the middle of the book
- Add a new page at the end of the book

Books as Data Structures

- Arrays are stored in memory like a normal book; it's **contiguous**, and **random-access**
- For the next three lectures, we'll discuss the data structure equivalent to a “choose your own adventure” book

### Mystery

3

```

1 List<Integer> list1 = new ArrayList<Integer>();
2 list1.add(8);
3 list1.add(3);
4 List<Integer> list2 = new ArrayList<Integer>();
5 list2.add(100);
6 List<Integer> list3 = list2;
7 list2 = list1;
8 list2.add(5);
9 list1.add(2);
10 System.out.println("A: " + list1);
11 System.out.println("B: " + list2);
12 System.out.println("C: " + list3);

```

What does this code print?

OUTPUT

```

>> A: [8, 3, 5, 2]
>> B: [8, 3, 5, 2]
>> C: [100]

```

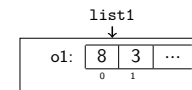
### Mystery Explained

4

```

1 List<Integer> list1 = new ArrayList<Integer>(); //o1
2 list1.add(8);
3 list1.add(3);

```



```

4 List<Integer> list2 = new ArrayList<Integer>(); //o2
5 list2.add(100);

```



```

6 List<Integer> list3 = list2;

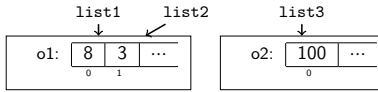
```



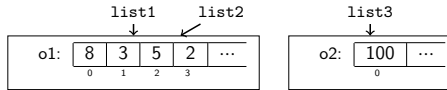
## Mystery Explained (cont.)

5

```
7 list2 = list1;
```



```
8 list2.add(5);
9 list1.add(2);
```



### What's Going On?

- The keyword **new** creates an actual new object to point to (o1, o2).
- All the other variables just point to objects that were created with new (list1, list2, list3).

## ListNode

6

### ListNode Class

```
1 public class ListNode {
2     int data;
3     ListNode next;
4 }
```

A ListNode is:



The **box** represents data, and the **arrow** represents next.

Since next is of ListNode type, the arrow can either point to nothing (null) or another ListNode.

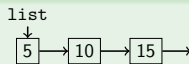
## ListNode

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### ListNode Class

```
1 public class ListNode {
2     int data;
3     ListNode next;
4 }
```

### How can we use code to make this list?



```
1 ListNode list = new ListNode();
2 list.data = 5;
3 list.next = new ListNode();
4 list.next.data = 10;
5 list.next.next = new ListNode();
6 list.next.next.data = 15;
```

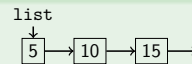
## ListNode

8

### ListNode Class

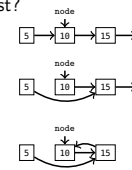
```
1 public class ListNode {
2     int data;
3     ListNode next;
4 }
```

### How can we use code to make this list?



What does this code do to our list?

```
1 ListNode node = list.next;
2 list.next = list.next.next;
3 list.next.next = node;
```



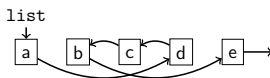
This isn't quite

What's wrong?

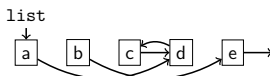
## Working With Linked Lists

9

```
list.next.next.next = list.next;
```



The code sets **the arrow** coming out of c to **the node** d.



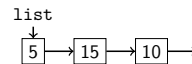
The **left side** of the assignment is **an arrow**.

The **right side** of the assignment is **a node**.

## Dereferencing

10

When we call `.next`, we follow an **arrow** in the list. What happens if we have this list:



And we call the following code:

```
1 System.out.println(list.next.next.next);
```

Or this code:

```
1 System.out.println(list.next.next.next.data);
```

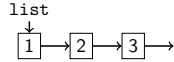
The first one prints null. The second throws a `NullPointerException`.

null means "end of the list"!

```
1 public class ListNode {
2     int data;
3     ListNode next;
4
5     public ListNode(int data) {
6         this(data, null);
7     }
8
9     public ListNode(int data, ListNode next) {
10        this.data = data;
11        this.next = next;
12    }
13 }
```

What list does this code make?

```
ListNode list = new ListNode(1, null);
list.next = new ListNode(2, null);
list.next.next = new ListNode(3, null);
```



Can we do this without ever using `.next`?

```
ListNode list = new ListNode(1, new ListNode(2, new ListNode(3, null)));
```