

Nodes

Poll

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A: Use a NULL reference

Poll

Q: Given the following code, what is printed? (Recall the simple `Point.java` class, with `x` and `y` instance variables & getters/setters)

```
public class UsePoint {  
    public static void main(String[] args) {  
        Point p = new Point(3, 2);  
        Point q = p;  
        p.setX(64);  
        System.out.println(q.getX());  
    }  
}
```

Poll

Q: Given the following code, what is printed? (Recall the simple `Point.java` class, with `x` and `y` instance variables & getters/setters)

A: **64**

```
public class UsePoint {  
    public static void main(String[] args) {  
        Point p = new Point(3, 2);  
        Point q = p;  
        p.setX(64);  
        System.out.println(q.getX());  
    }  
}
```

Previously: Arrays

Previously, if we ever wanted to store a sequence of data, we used arrays (or ArrayLists, which are just arrays that Java manages in fancy ways for you.)

- Arrays store data in contiguous memory (each element is next to each other in memory)
- We could access a specific position with an index

Example array declaration: `int[] values = {2814, 2048, 867, 5309};`

0	1	2	3
2814	2048	867	5309

Array Flaws

What if we wanted to add a new value to the beginning of an array?

- All we have is a variable `values` that stores a reference to an array object in memory
- That array object is a contiguous portion of "heap" space that takes up a fixed amount of space

0	1	2	3
2814	2048	867	5309

Array Flaws

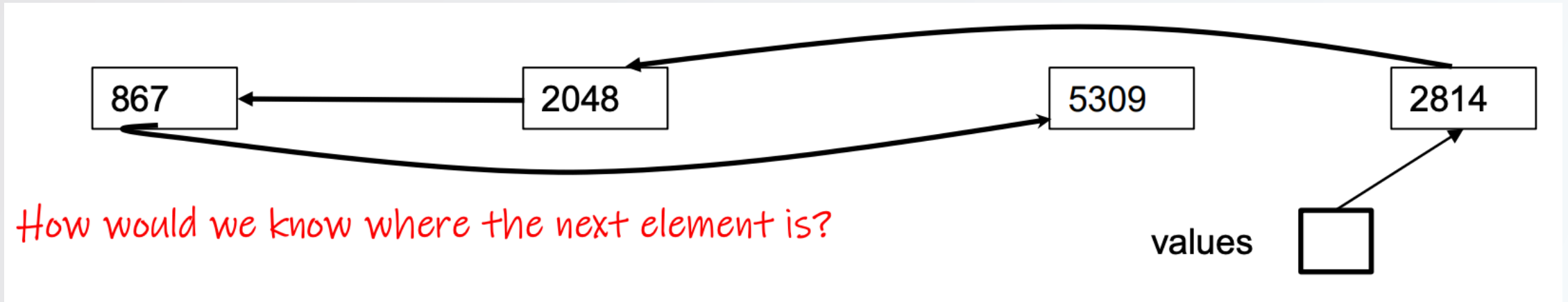
What if we wanted to add a new value to the beginning of an array?

Need to:

- create a new array object (using `new`) with a bigger size
- copy over old values to positions `1-4`
- and then insert new value at position `0`

Idea: Non-contiguous Storage

What if we tried to store data in memory that is noncontiguous, where each element is spread apart from one another?



Want to:

- Keep track of the first element (just like arrays)
- have each value store a reference to the "next" value

Introduction: Nodes

Node: a class containing one or more data fields that store data, and a *reference* to another linked node

- connect these objects together to form a structure of linked nodes

Linked nodes are the building blocks of programs (data structures) that store a large amount of data without using an array

- Allow us to more easily modify a collection of data
- Don't have to worry about knowing the length before hand

Node Class

Two examples, one for each kind of data that the node will store.

```
public class Node {  
    public Node next; // Point to next node  
    public int data; // Value (int) for this node  
    public Node(int data, Node next) {  
        this.data = data;  
        this.next = next;  
    }  
    // data fields are public, no need for getters and setters  
}
```

```
public class Node {  
    public Node next; // Point to next node  
    public Computer data; // Value (Computer) for this node  
    public Node(Computer data, Node next) {  
        this.data = data;  
        this.next = next;  
    }  
}
```

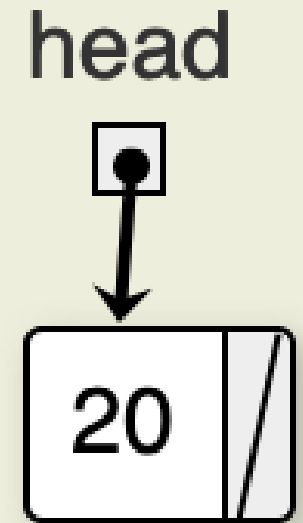
Chain of Nodes: Starting the Chain

Let's build a chain of nodes! Each node stores an integer value and a reference to another Node.

```
Node head = new Node(20, null);
```

The `next` (following) node of head's pointee is a **null reference**

The `data` stored in head's pointee is **20**

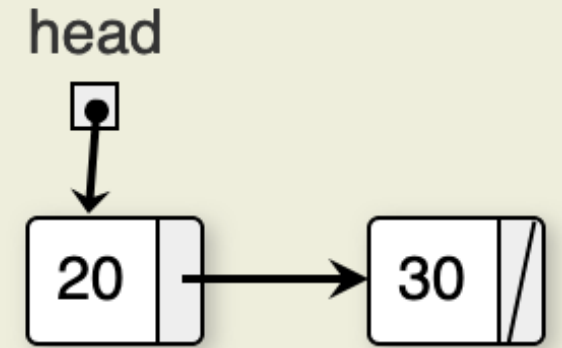


Chain of Nodes: Adding a Follower

To add a new node at the end of the chain, we must construct a new `Node` and point the `head` node to it.

```
head.next = new Node(30, null);
```

The `next` (follower) node of `head`'s pointee is a new `Node` storing `30` as its `data`

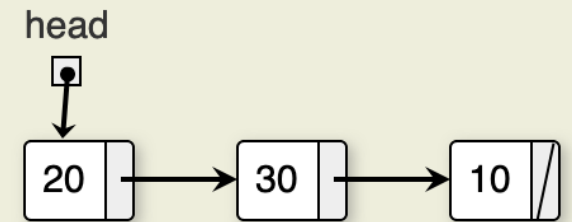


Chain of Nodes: Adding Another Follower

Chain of nodes

```
head.next.next = new Node(10, null);
```

The `next` (follower) node of `head`'s follower is a new `Node` storing `10` as its `data`.

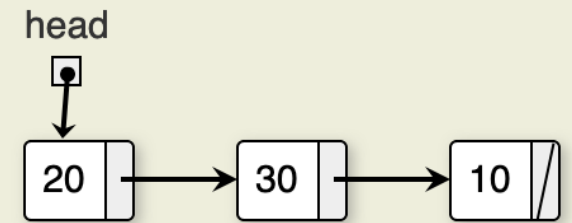


Chain of Nodes: All at Once

Putting everything together:

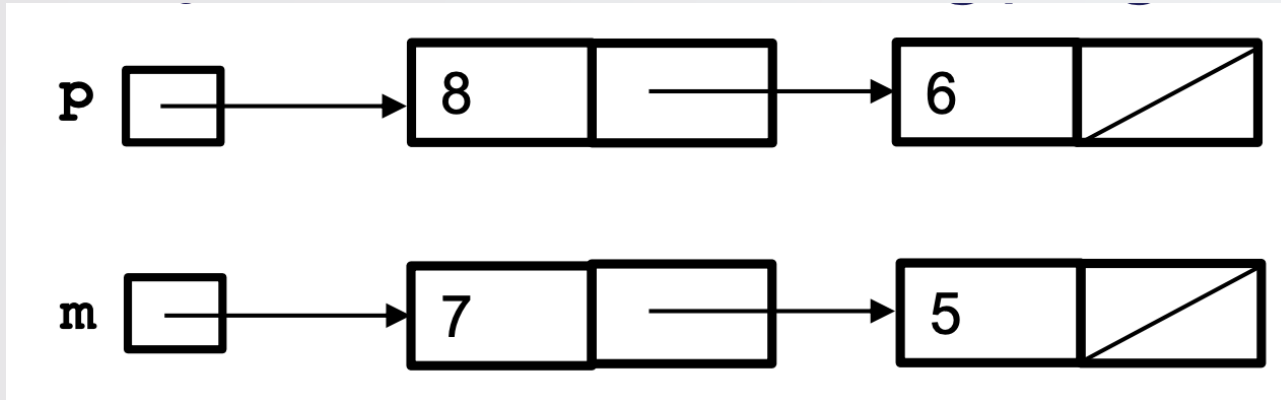
```
Node head = new Node(20, null);  
head.next = new Node(30, null);  
head.next.next = new Node(10, null);
```

The last node has `null` as its `next` to mark that there are no more nodes.

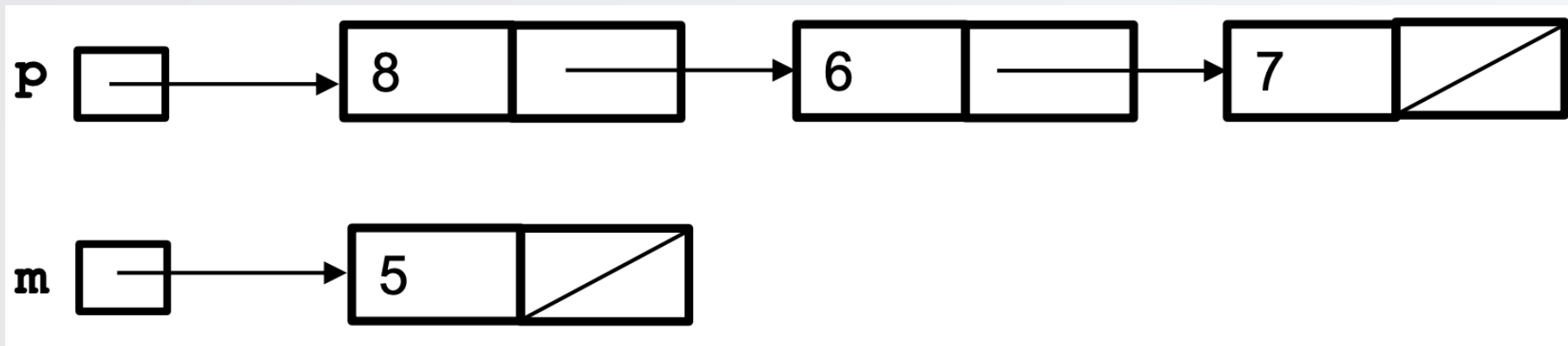


Practice Working with Nodes

How can we get from this program state:



To this program state? (Without modifying node data directly...)



Chain of nodes: iteration

To iterate through a chain of nodes:

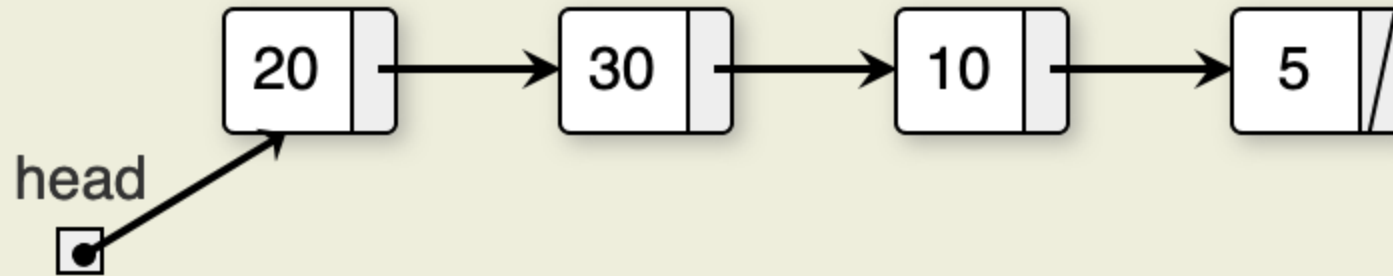
- We don't need to know how many nodes are in the chain
- Just know that the last `node`'s `next` field is a `null` reference

Steps:

- Create a temporary node **variable** that starts by pointing to the head of the chain (sharing)
- Iterate/loop by following the next references with each iteration, update the pointee of the temporary node
- Stop when the temporary node points to a null reference

Chain of nodes: iteration

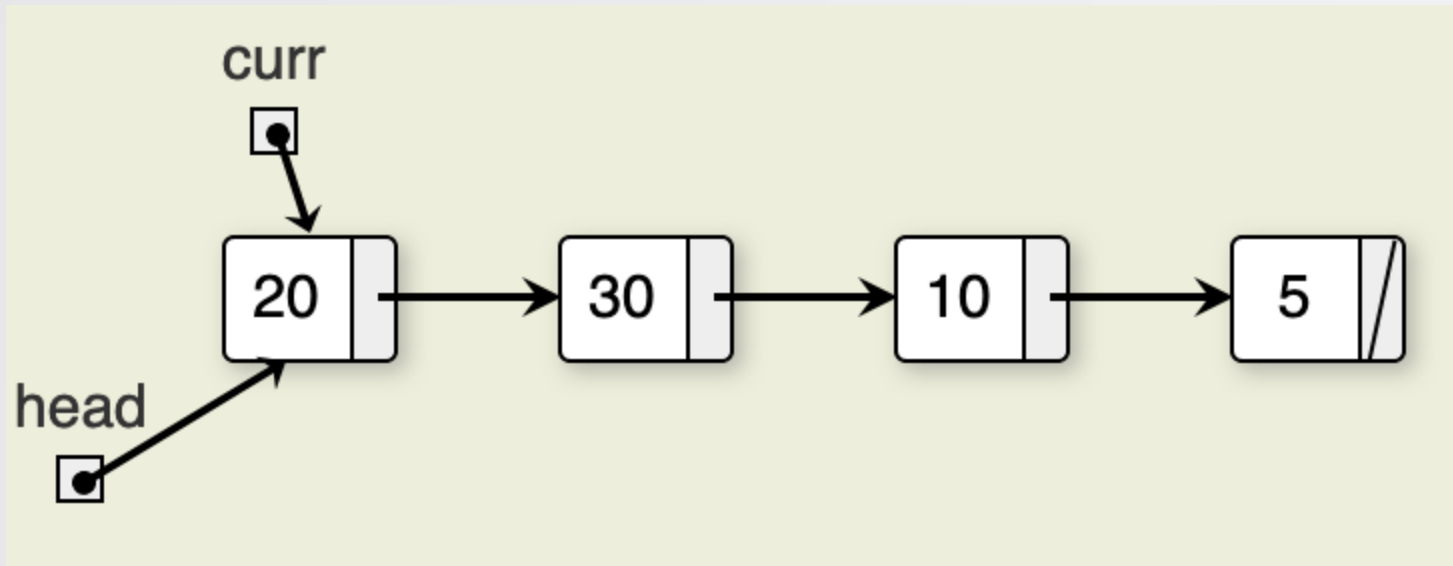
Given the following chain...



Chain of nodes: iteration

Create a temporary node that points to the head of the chain

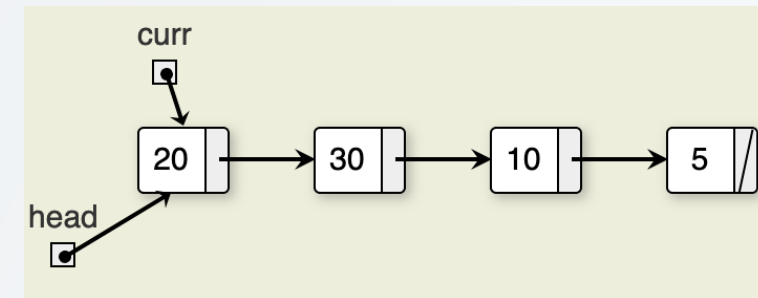
```
Node curr = head; //curr and head are aliases for each other
```



Chain of nodes: iteration

Start the loop & stop when `curr` points to the last node in the chain

```
Node curr = head; //curr and head are aliases for each other
while (curr != null) { // while the pointee of curr is not null,
    curr = curr.next;    // advance curr to point to the next node.
}
```

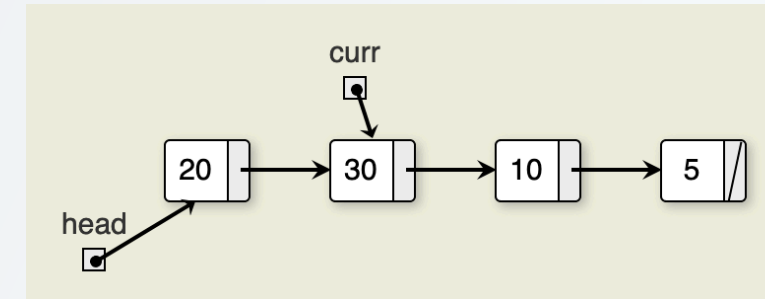


Chain of nodes: iteration

`curr` now points to the node storing 30

```
Node curr = head; //curr and head are aliases for each other
while (curr != null) { // while the pointee of curr is not null,
    curr = curr.next;    // advance curr to point to the next node.
}
```

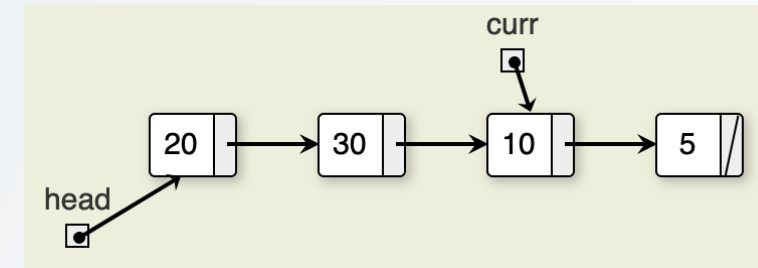
Note that `head` did not move.



Chain of nodes: iteration

`curr` now points to the node storing 10

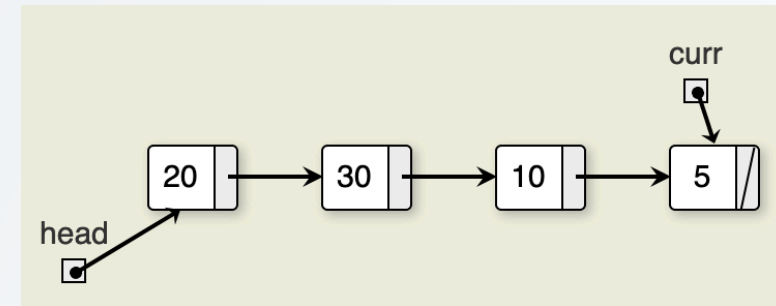
```
Node curr = head; //curr and head are aliases for each other
while (curr != null) { // while the pointee of curr is not null,
    curr = curr.next;    // advance curr to point to the next node.
}
```



Chain of nodes: iteration

Curr now points to the node storing 5

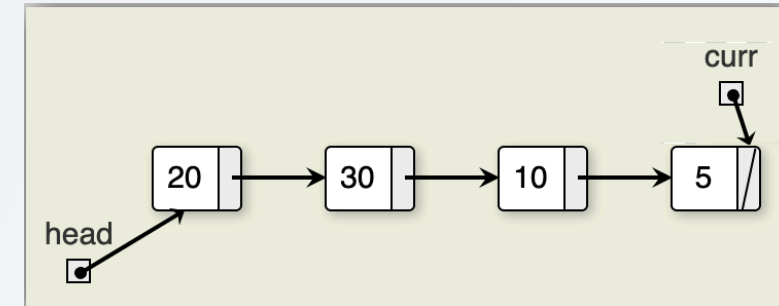
```
Node curr = head; //curr and head are aliases for each other
while (curr != null) { // while the pointee of curr is not null,
    curr = curr.next;    // advance curr to point to the next node.
}
```



Chain of nodes: iteration

Curr is now a null reference

```
Node curr = head; //curr and head are aliases for each other
while (curr != null) { // while the pointee of curr is not null,
    curr = curr.next;    // advance curr to point to the next node.
}
```



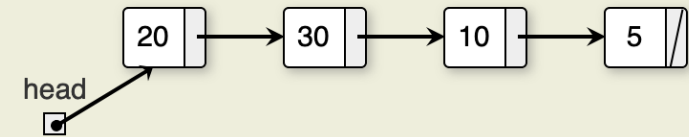
Chain of nodes: iteration

Putting everything together:

The following code will print all the values stored in our chain

```
Node curr = head; //curr and head are aliases for each other
while (curr != null) {
    System.out.println(curr.data);
    curr = curr.next;
}
```

Will print: 20 30 10 5



Chain of nodes: iteration (for loop)

As a for loop instead:

```
for (Node curr = head; curr != null; curr = curr.next) {  
    System.out.println(curr.data);  
}
```

Will print: 20 30 10 5

