Building Java Programs

Chapter 16

Linked List Basics

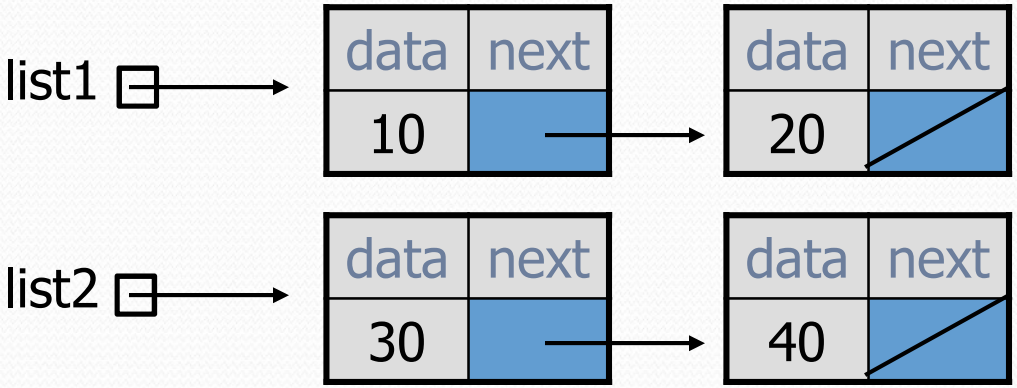
reading: 16.2

LinkedList Week*

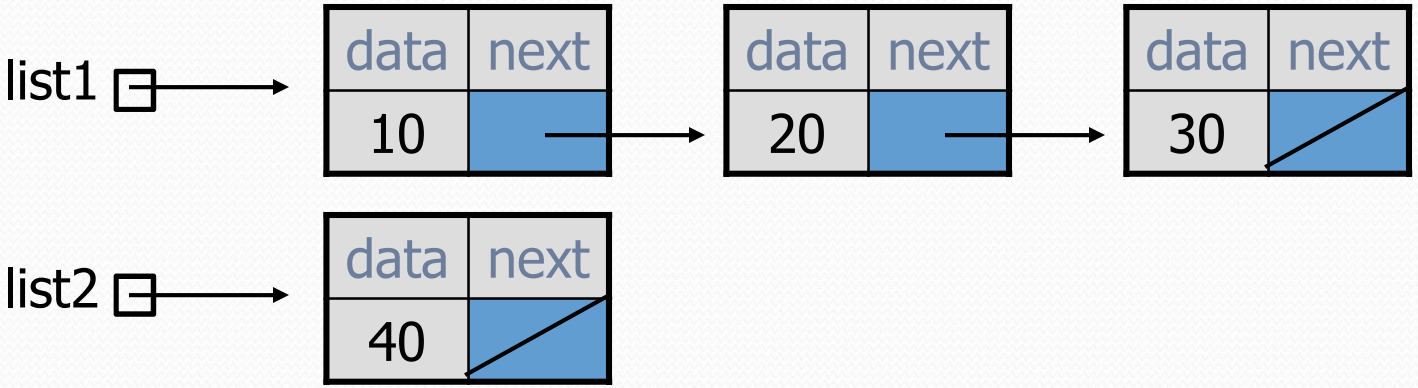
- Friday 1/18
  - Intro to ListNodes and Before/After pictures
- Tuesday 1/22
  - Practice with Before/After pictures
- Wednesday 1/23
  - Intro to LinkedIntList
  - ListNodes and Loops
- Thursday 1/24
  - Practice with ListNodes and loops
- Friday 1/25
  - Advanced loops with ListNodes
- Tuesday 1/29
  - Practice with advanced loops

Linked node problem 3

- What set of statements turns this picture:

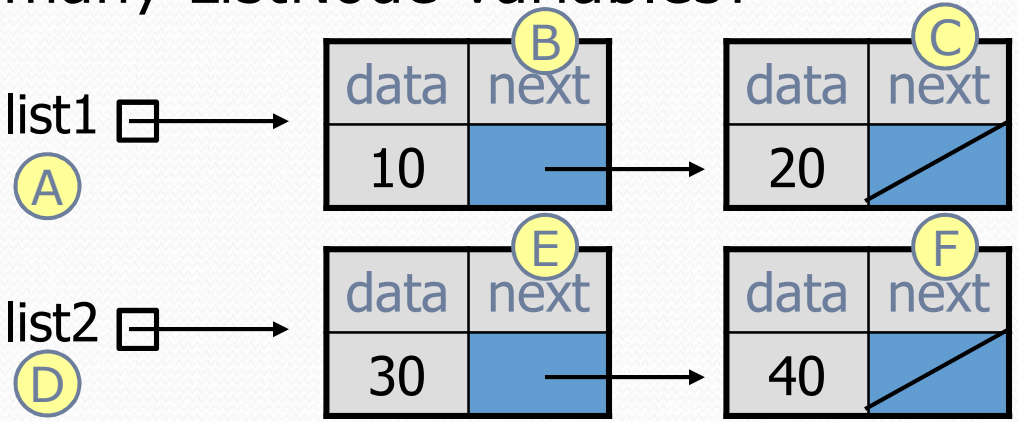


- Into this?

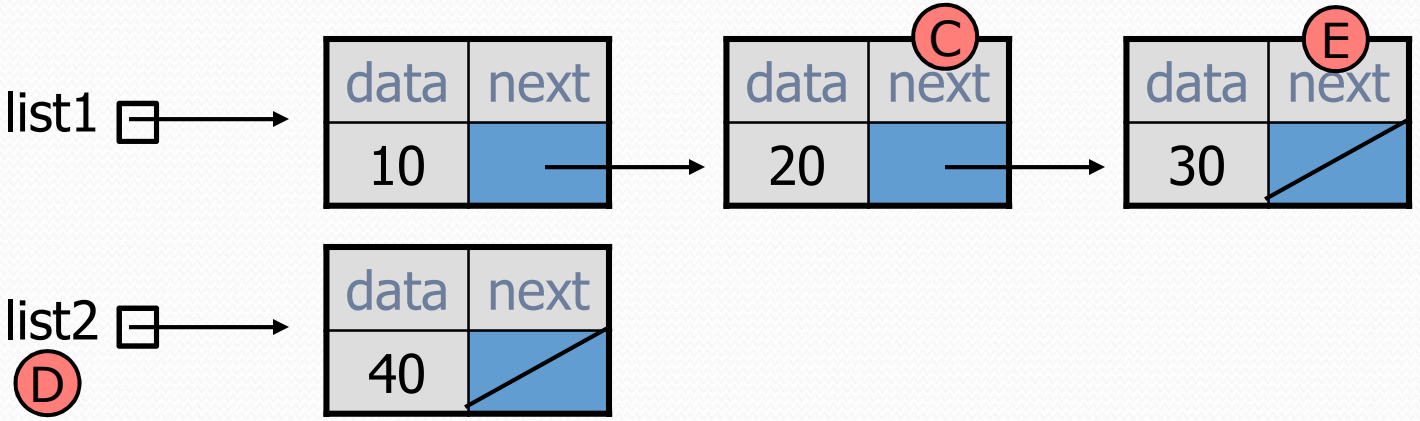


Linked node problem 3

- How many ListNode variables?



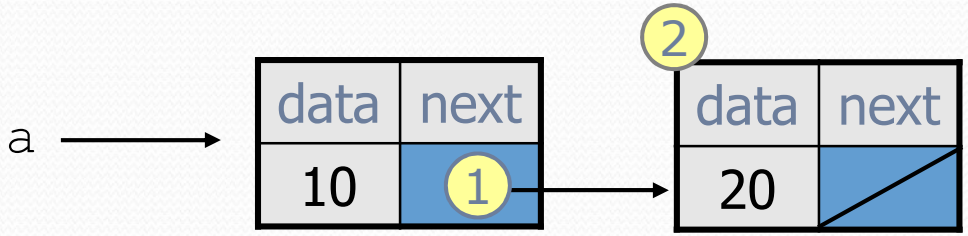
- Which variables change?



References vs. objects

variable = **value**;

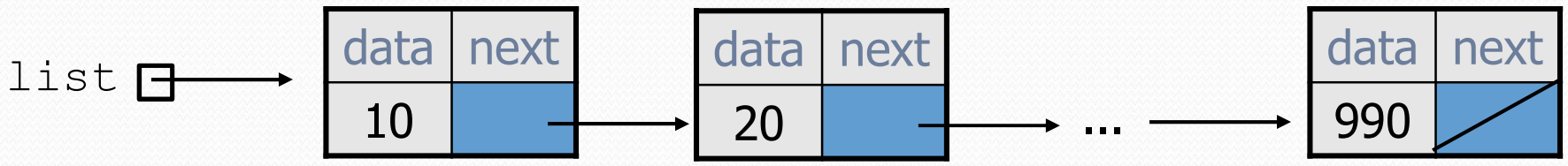
a *variable* (left side of =) place to put a reference
(where the phone number goes; where the base of the arrow goes)
a *value* (right side of =) is the reference itself
(the phone number; the destination of the arrow)



- For the list at right:
  - `a.next` = **value**;
    means to adjust where (1) points
  - **variable** = `a.next;`
    means to make **variable** point at (2)

Linked node question

- Suppose we have a long chain of list nodes:



  - We don't know exactly how long the chain is.

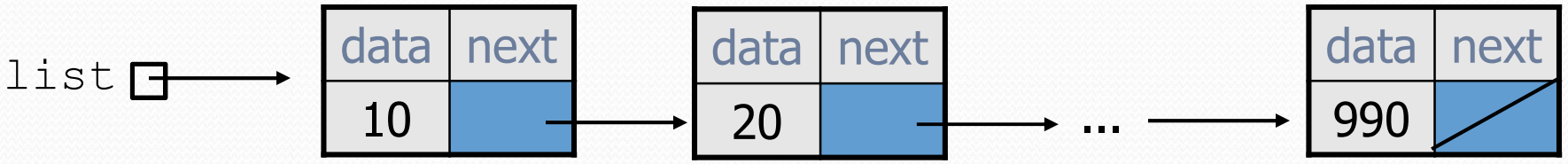
- How would we print the data values in all the nodes?

Algorithm pseudocode

```
Start at the front of the list.
While (there are more nodes to print):
   Print the current node's data.
   Go to the next node.
```

- How do we walk through the nodes of the list?

```
list = list.next;    // is this a good idea?
```

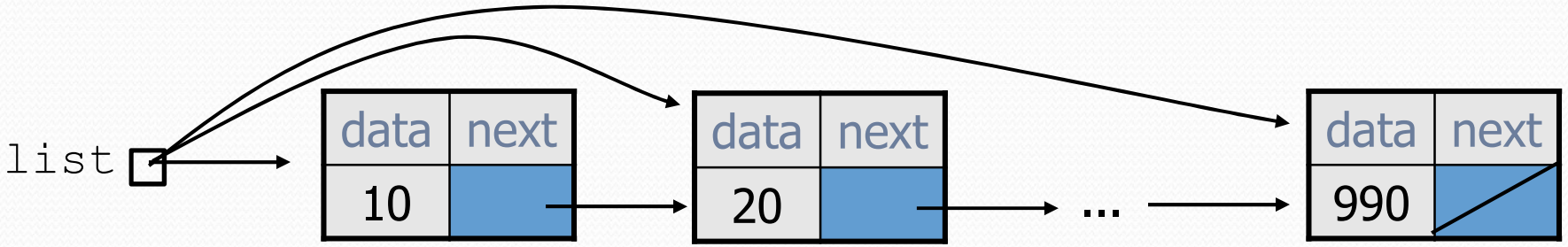


Traversing a list?

- One (bad) way to print every value in the list:

```
while (list != null) {
    System.out.println(list.data);
    list = list.next;     // move to next node
}
```

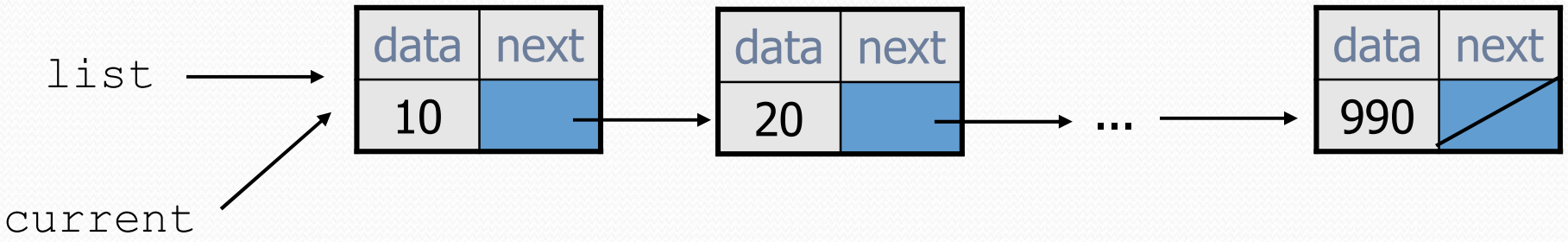
  - What's wrong with this approach?
    - (It loses the linked list as it prints it!)



A `current` reference

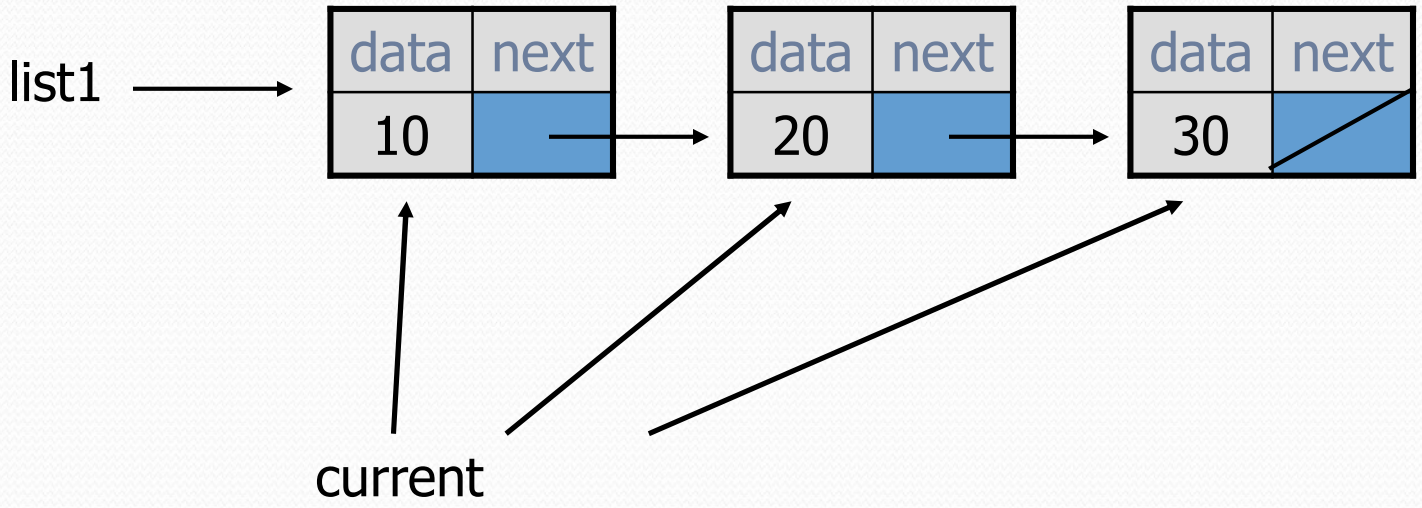
- Don't change `list`. Make another variable, and change it.
  - A `ListNode` variable is NOT a `ListNode` object

```
ListNode current = list;
```



- What happens to the picture above when we write:

```
current = current.next;
```

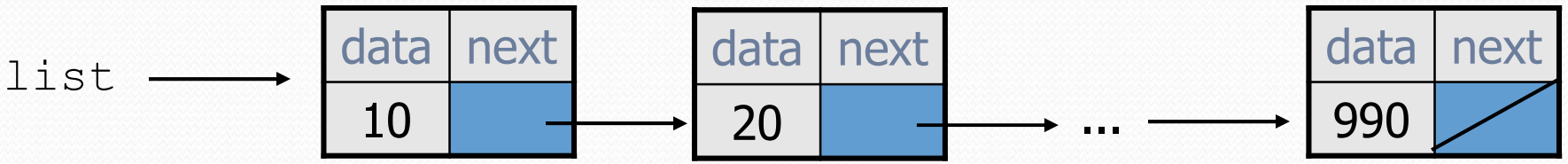

list1
data
next
10
data
next
20
data
next
30
current

Traversing a list correctly

- The correct way to print every value in the list:

```
ListNode current = list;
while (current != null) {
    System.out.println(current.data);
    current = current.next;  // move to next node
}
```

  - Changing `current` does not damage the list.



Abstract data types (ADTs)

- **abstract data type (ADT)**: A specification of a collection of data and the operations that can be performed on it.
  - Describes *what* a collection does, not *how* it does it

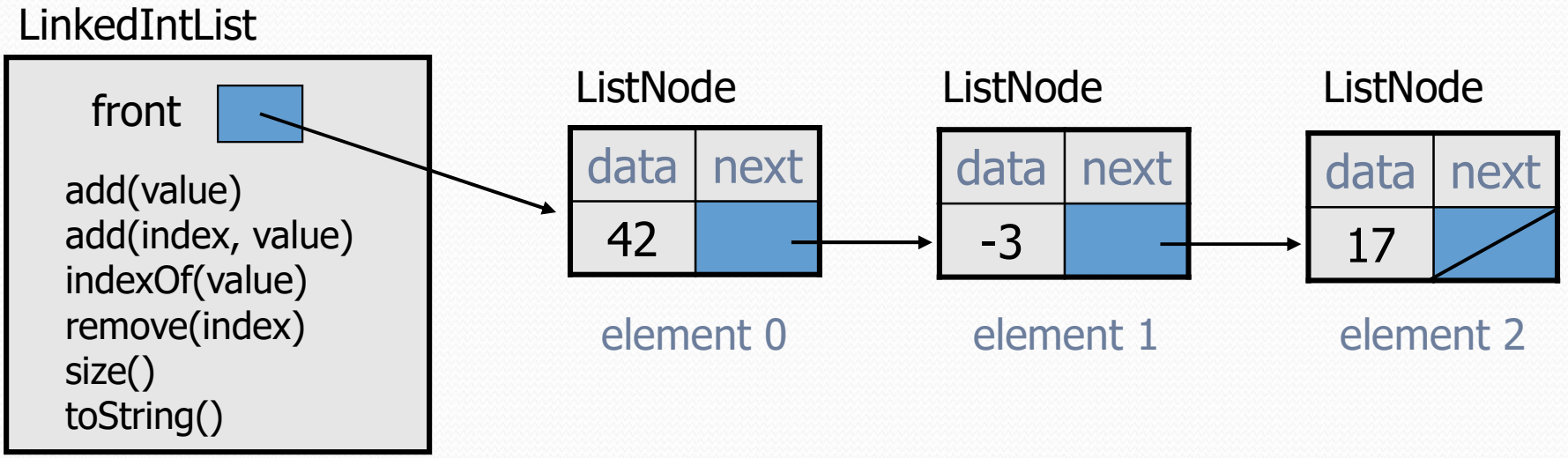
- Java's collection framework describes several ADTs:
  - `Queue`, `List`, `Collection`, `Deque`, `List`, `Map`, `Set`

- An ADT can be implemented in multiple ways:
  - `ArrayList` and `LinkedList` implement `List`
  - `HashSet` and `TreeSet` implement `Set`
  - `LinkedList`, `ArrayDeque`, etc. implement `Queue`

- The **same** external behavior can be implemented in many different ways, each with pros and cons.

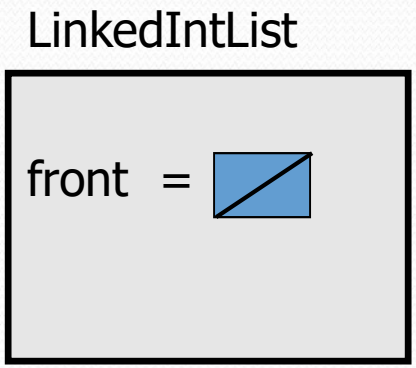
A `LinkedIntList` class

- Let's write a collection class named `LinkedIntList`.
  - Has the same methods as `ArrayIntList`:
    - `add`, `add`, `get`, `indexOf`, `remove`, `size`, `toString`
  - The list is internally implemented as a chain of linked nodes
    - The `LinkedIntList` keeps a reference to its `front` as a field
    - `null` is the end of the list; a `null` front signifies an empty list



LinkedIntList class v1

```
public class LinkedIntList {
    private ListNode front;

    public LinkedIntList() {
        front = null;
    }

    methods go here

}
```



Linked List vs. Array

- Print list values:

```
ListNode list= ...;

ListNode current = list;
while (current != null) {
    System.out.println(current.data);
    current = current.next;
}
```

- Similar to array code:

```
int[] a = ...;

int i = 0;
while (i < a.length) {
    System.out.println(a[i]);
    i++;
}
```

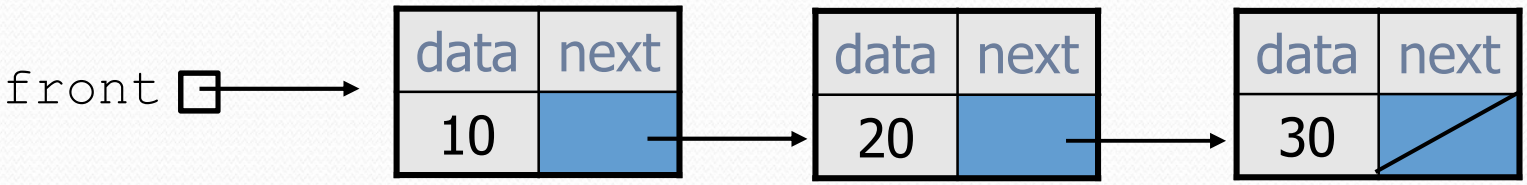
Description	Array Code	Linked List Code
Go to front of list	`int i = 0;`	`ListNode current = list;`
Test for more elements	`i < size`	`current != null`
Current value	`elementData[i]`	`current.data`
Go to next element	`i++; // i=i+1`	`current = current.next;`

Poll Everywhere Workflow

1. Think (1 minute)
   1. Take **45 seconds** to think *on your own* about the problem
   2. Take **15 seconds** to poll in *by yourself*
2. Pair (2 minutes) [TAs will walk around]
   1. Take **1.5 minutes** to *talk with your neighbors* about the problem and compare how you answered
      - If you and your neighbors agree, try to figure out why the other answers might be wrong
      - If you and your neighbors disagree, talk about the material to figure out who is right!
   2. Take **30 seconds** to finish discussion and poll in with your new final answer
3. Share (2 minutes)
   1. Talk as a class about what people were answering in and why

Poll Everywhere pollev.com/cse143

- Suppose our list had the contents



- Practice simulating the code we wrote and tell us what the result will look like when we call `list.add(40);`

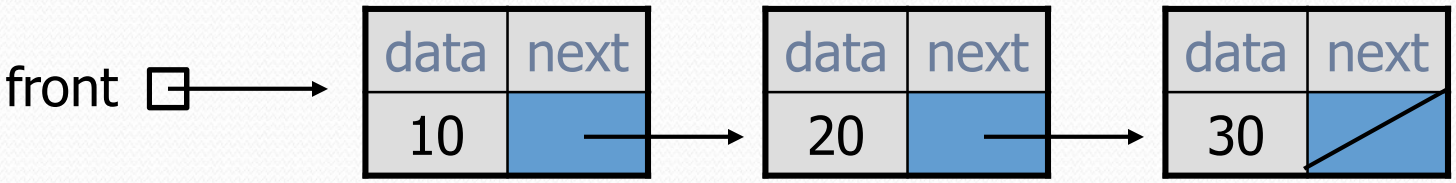
```
public void add(int value) {
    ListNode curr = front;
    while (curr != null) {
        curr = curr.next;
    }
    curr = new ListNode(value);
}
```

Options

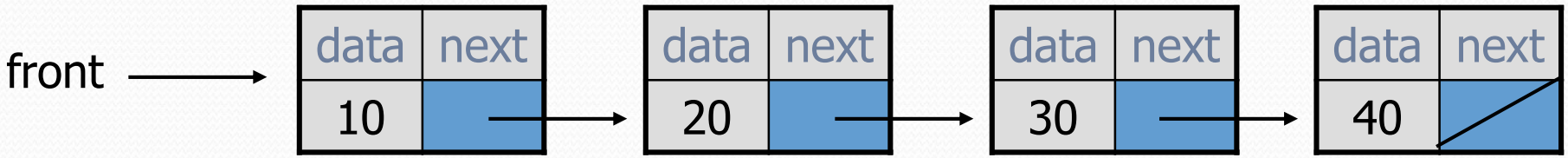
- [10, 20, 30]
- [10, 20, 40]
- [10, 20, 40, 30]
- [10, 20, 30, 40]
- Error

Before/After

- Before



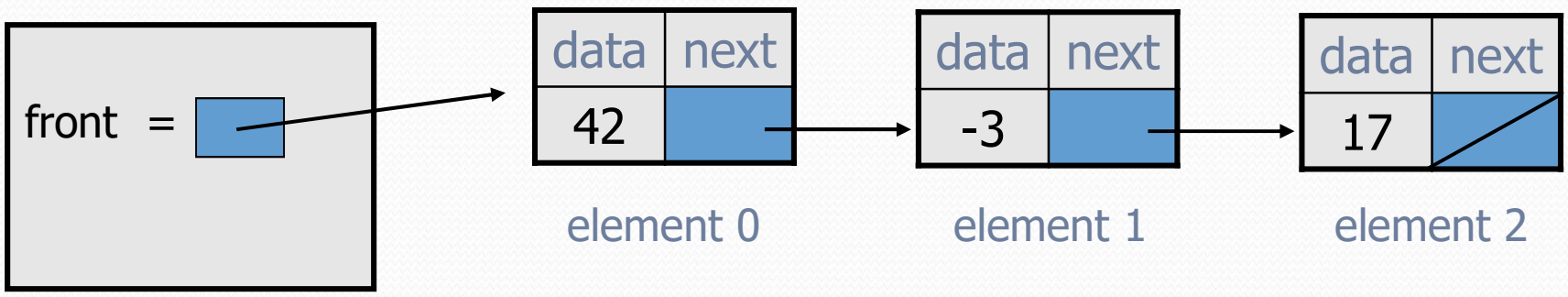
- After



Implementing `add`

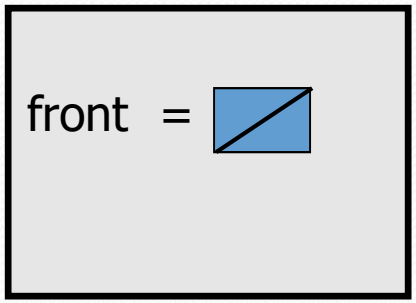
```
// Adds the given value to the end of the list.
public void add(int value) {
    ...
}
```

- How do we add a new node to the end of a list?
- Does it matter what the list's contents are before the add?

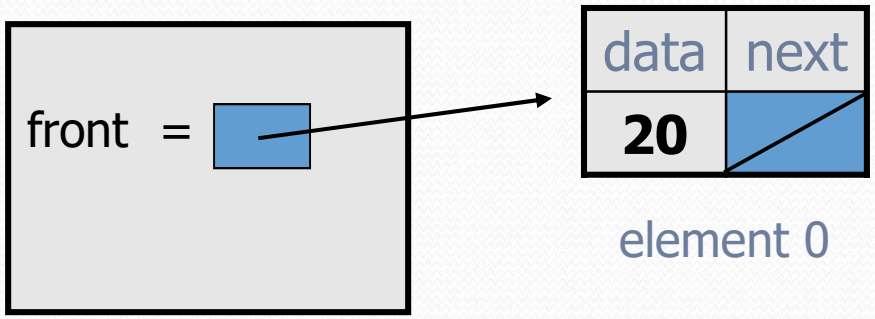


Adding to an empty list

- Before adding 20:



After:



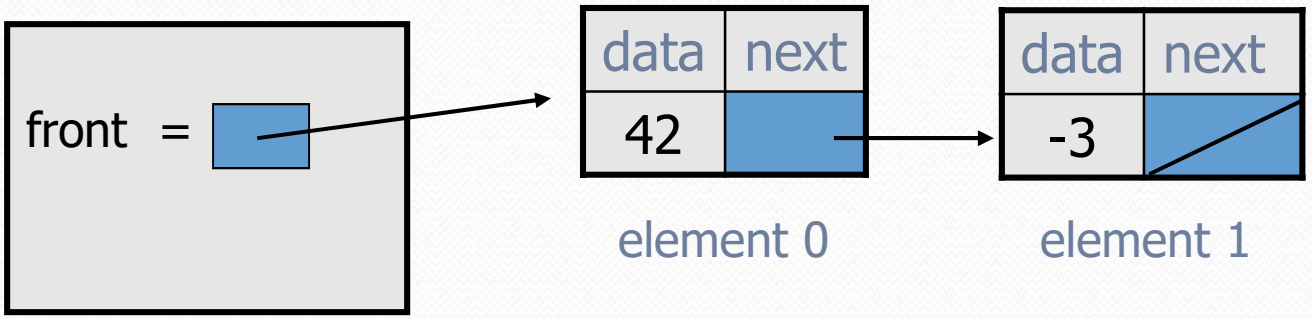
  - We must create a new node and attach it to the list.

The `add` method, 1st try

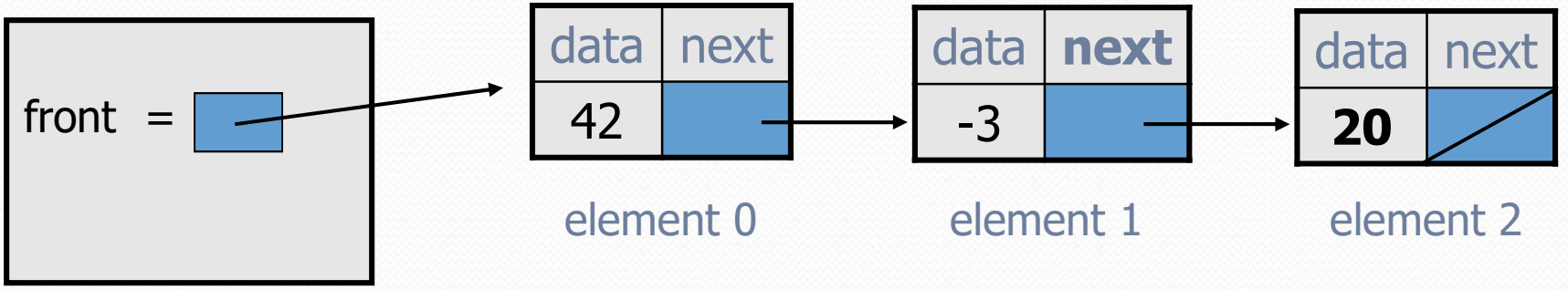
```
// Adds the given value to the end of the list.
public void add(int value) {
    if (front == null) {
        // adding to an empty list
        front = new ListNode(value);
    } else {
        // adding to the end of an existing list

        ...

    }
}
```

Adding to non-empty list

- Before adding value 20 to end of list:

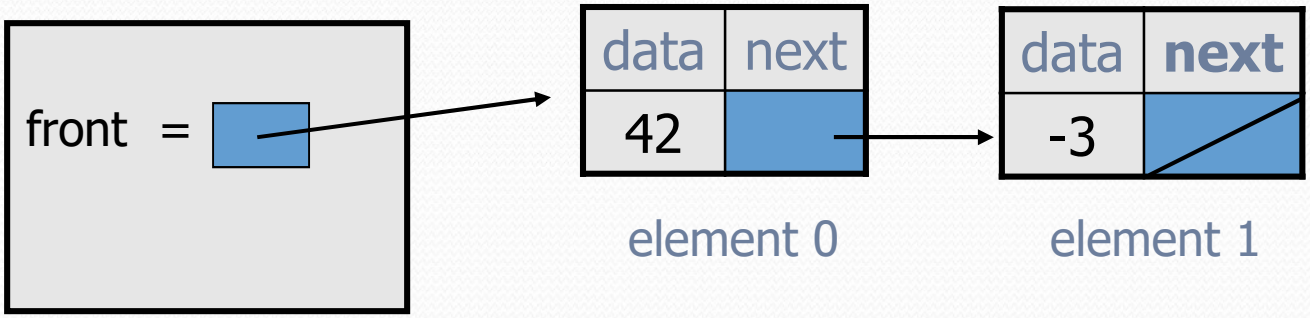


- After:



Don't fall off the edge!

- To add/remove from a list, you must modify the `next` reference of the node *before* the place you want to change.



  - Where should `current` be pointing, to add 20 at the end?
  - What loop test will stop us at this place in the list?

The `add` method

```
// Adds the given value to the end of the list.
public void add(int value) {
    if (front == null) {
        // adding to an empty list
        front = new ListNode(value);
    } else {
        // adding to the end of an existing list
        ListNode current = front;
        while (current.next != null) {
            current = current.next;
        }
        current.next = new ListNode(value);
    }
}
```

changing a list

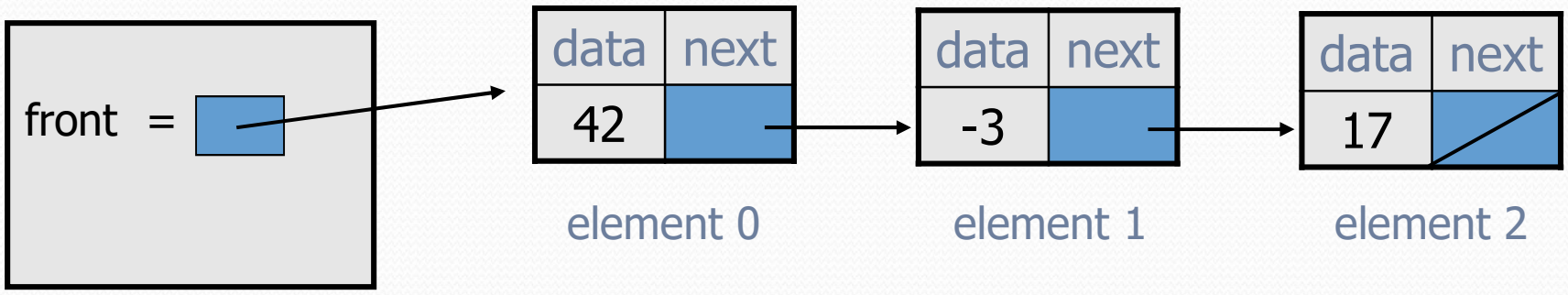
- There are only two ways to change a linked list:
  - Change the value of `front` (modify the front of the list)
  - Change the value of `<node>.next` (modify middle or end of list to point somewhere else)

- Implications:
  - To add in the middle, need a reference to the *previous* node
  - Front is often a special case

Implementing `get`

```
// Returns value in list at given index.
public int get(int index) {
    ...
}
```

- Exercise: Implement the `get` method.



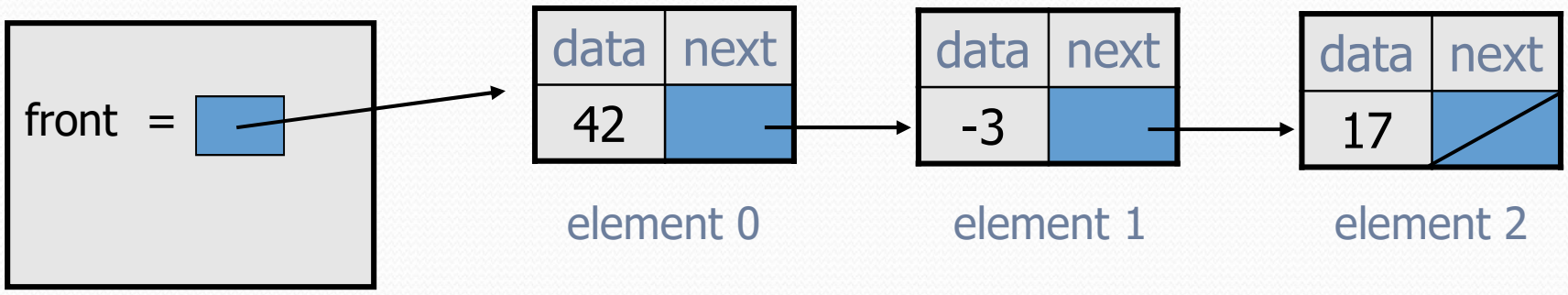
The `get` method

```
// Returns value in list at given index.
// Precondition: 0 <= index < size()
public int get(int index) {
    ListNode current = front;
    for (int i = 0; i < index; i++) {
        current = current.next;
    }
    return current.data;
}
```

Implementing `add` (2)

```
// Inserts the given value at the given index.
public void add(int index, int value) {
    ...
}
```

- Exercise: Implement the two-parameter `add` method.



The `add` method (2)

```
// Inserts the given value at the given index.
// Precondition: 0 <= index <= size()
public void add(int index, int value) {
    if (index == 0) {
        // adding to an empty list
        front = new ListNode(value, front);
    } else {
        // inserting into an existing list
        ListNode current = front;
        for (int i = 0; i < index - 1; i++) {
            current = current.next;
        }
        current.next = new ListNode(value,
                                    current.next);
    }
}
```