

Building Java Programs

Chapter 16

Lecture 16-2: Linked List Basics

reading: 16.2

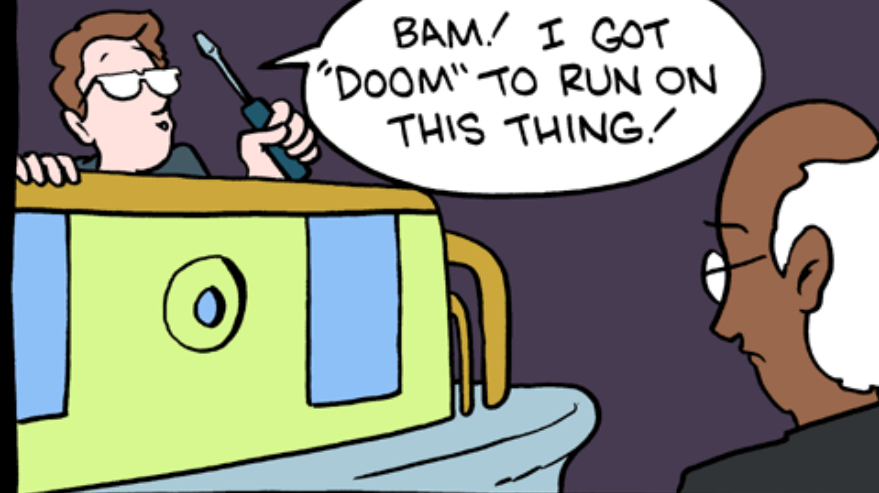
COMPUTER SCIENTIST

THIS ALIEN COMPUTER HAS AN ARCHITECTURE ENTIRELY FOREIGN TO OURS. WE HAVE MUCH TO LEARN FROM IT. AND WE MAY HAVE MUCH... TO FEAR.



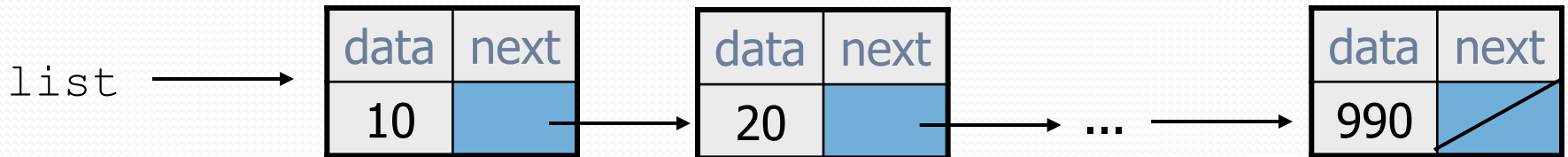
COMPUTER ENGINEER

BAM! I GOT "DOOM" TO RUN ON THIS THING!



Linked node question

- Suppose we have a long chain of list nodes:

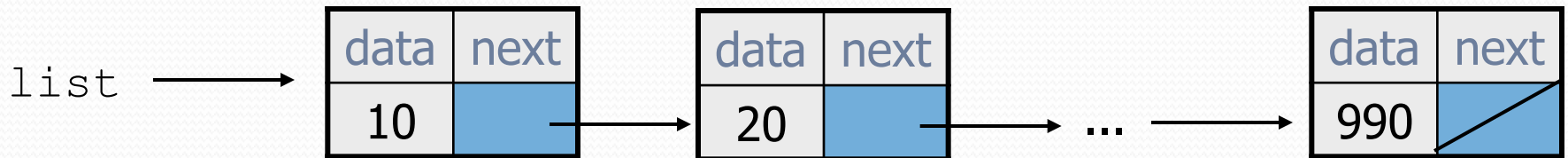


- We don't know exactly how long the chain is.
- How would we print the data values in all the nodes?

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?
```



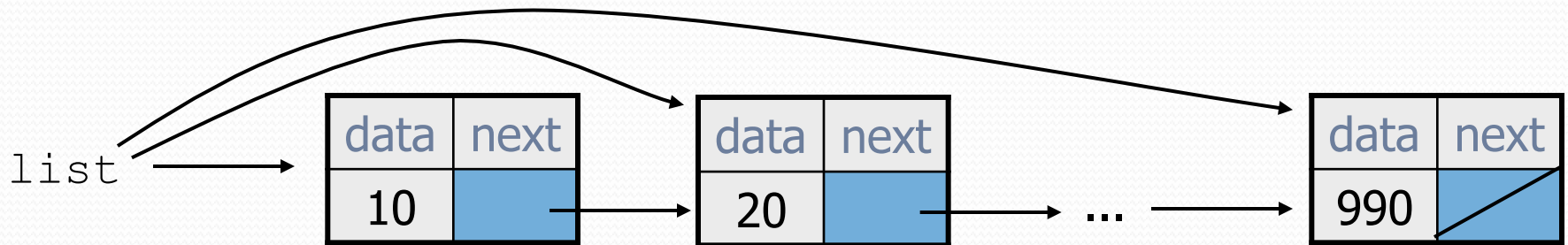
Traversing a list?

- 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  
}
```



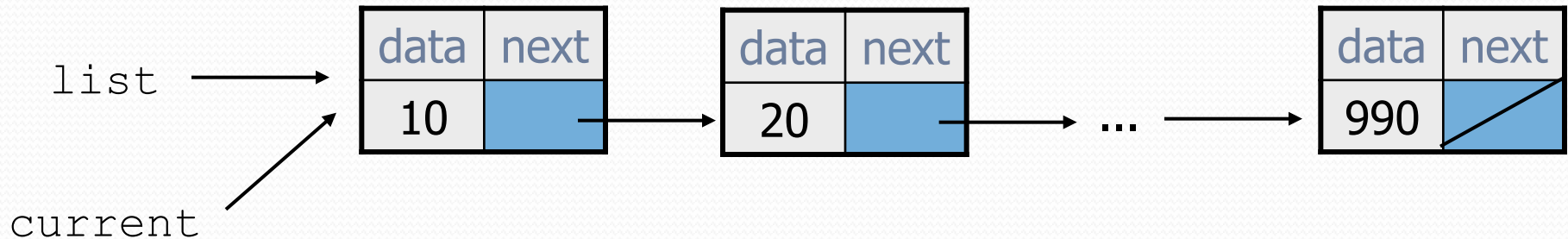
- What's wrong with this approach?
 - (It loses the linked list as it prints it!)



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;
```

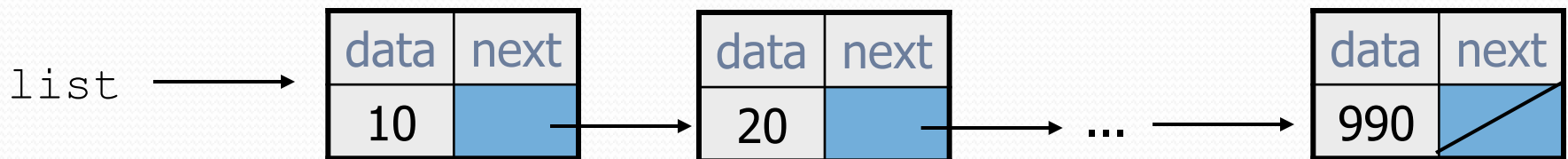
Traversing a list correctly

- 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.



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	<code>int i = 0;</code>	<code>ListNode current = list;</code>
Test for more elements	<code>i < size</code>	<code>current != null</code>
Current value	<code>elementData[i]</code>	<code>current.data</code>
Go to next element	<code>i++;</code>	<code>current = current.next;</code>

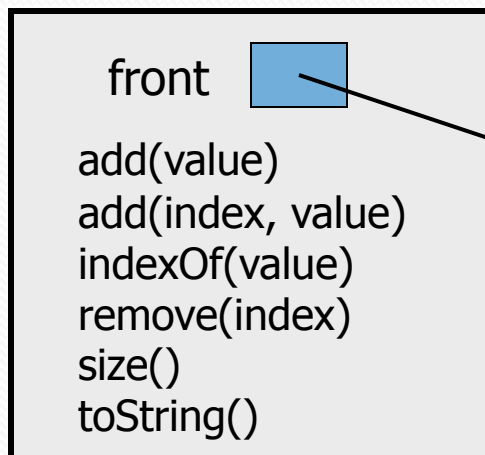
Abstract data types (ADTs)

- **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`, `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.

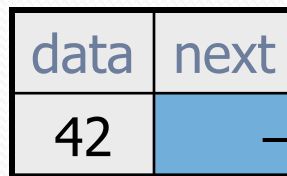
A `LinkedList` class

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

`LinkedList`

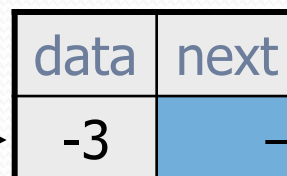


`ListNode`



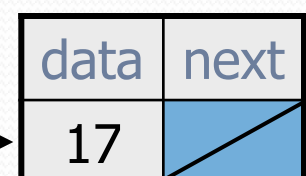
element 0

`ListNode`



element 1

`ListNode`

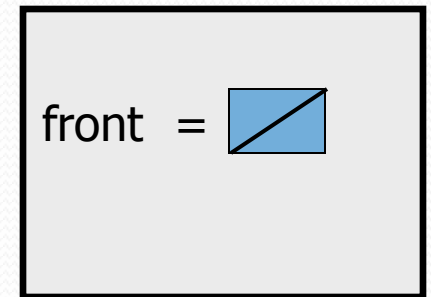


element 2

LinkedList class v1

```
public class LinkedList {  
    private ListNode front;  
  
    public LinkedList() {  
        front = null;  
    }  
  
    methods go here  
  
}
```

LinkedList

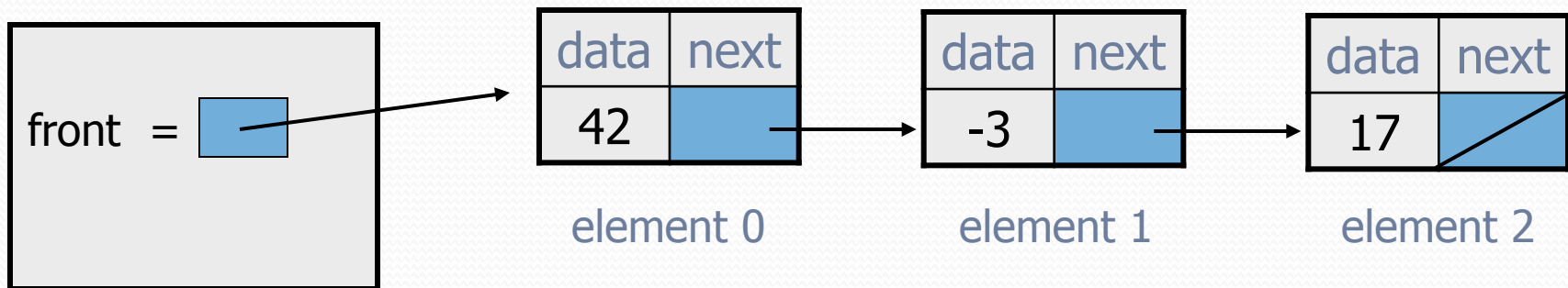


Implementing add

// Adds the given value to the end of the list.

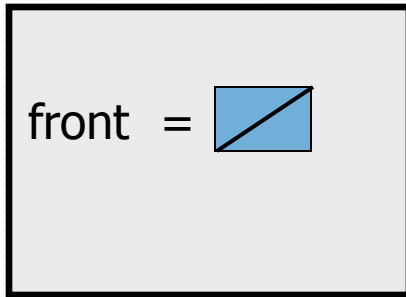
```
public void add(int value) {  
    ...  
}
```

- 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?

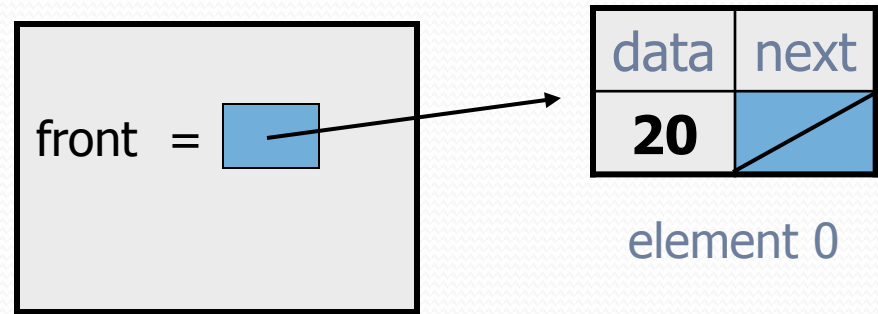


Adding to an empty list

- Before adding 20:



After:



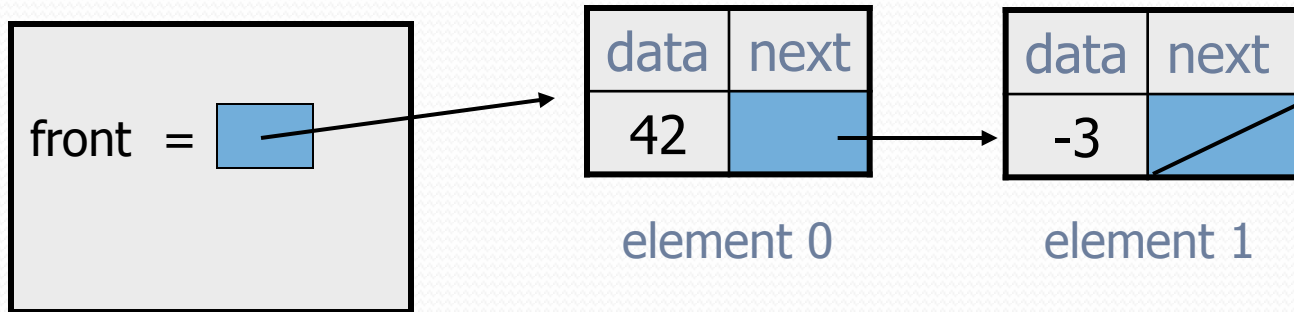
- We must create a new node and attach it to the list.

The add method, 1st try

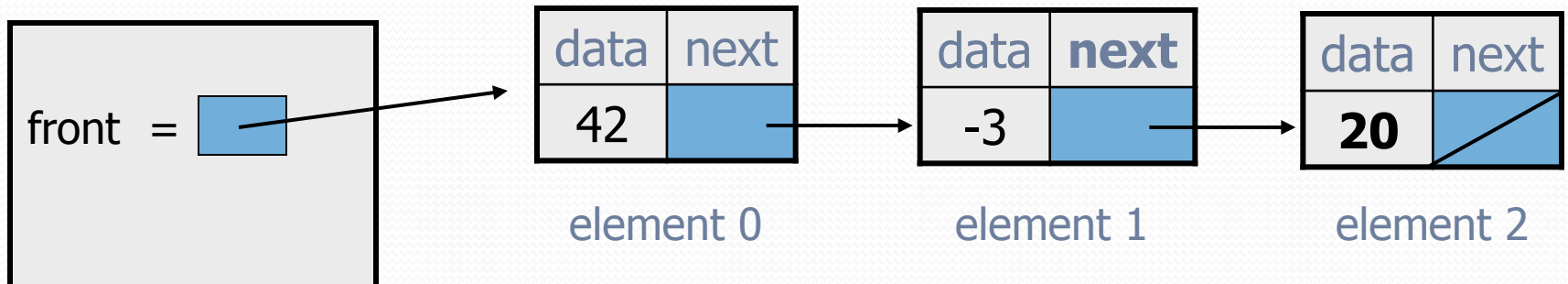
```
// Adds the given value to the end of the list.  
public void add(int value) {  
    if (front == null) {  
        // adding to an empty list  
        front = new ListNode(value);  
    } else {  
        // adding to the end of an existing list  
  
        ...  
    }  
}
```

Adding to non-empty list

- Before adding value 20 to end of list:

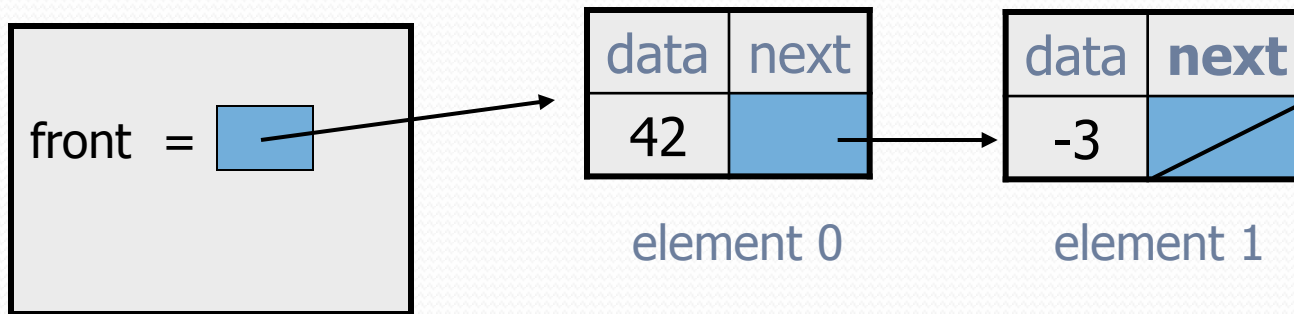


- After:



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?

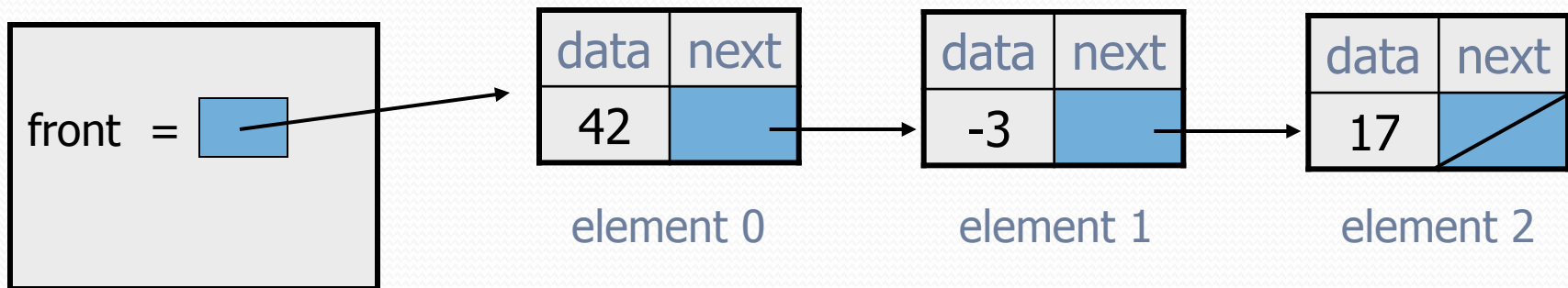
The add method

```
// 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);
    }
}
```

Implementing get

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

- Exercise: Implement the `get` method.



The get method

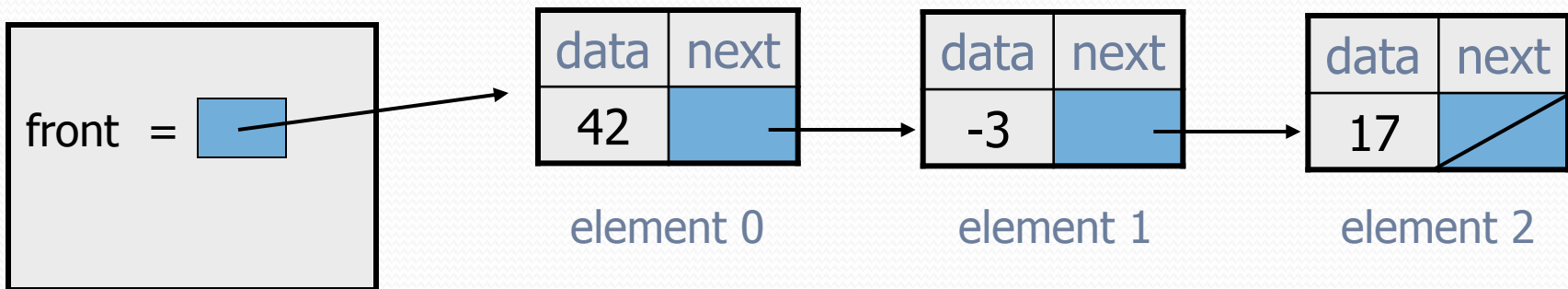
```
// Returns value in list at given index.  
// Precondition: 0 <= index < size()  
public int get(int index) {  
    ListNode current = front;  
    for (int i = 0; i < index; i++) {  
        current = current.next;  
    }  
    return current.data;  
}
```

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);
    }
}
```