CSE 143
Lecture 15

Sets and Maps; Iterators

reading: 11.1 - 11.3; 13.2; 15.3; 16.5

slides adapted from Marty Stepp

http://www.cs.washington.edu/143/

Sets and ordering

- `HashSet` : elements are stored in an unpredictable order

```
Set<String> names = new HashSet<String>();
names.add("Jake");
names.add("Robert");
names.add("Marisa");
names.add("Kasey");
System.out.println(names);
// [Kasey, Robert, Jake, Marisa]
```

- `TreeSet` : elements are stored in their "natural" sorted order

```
Set<String> names = new TreeSet<String>();
...
// [Jake, Kasey, Marisa, Robert]
```

- `LinkedHashSet` : elements stored in order of insertion

```
Set<String> names = new LinkedHashSet<String>();
...
// [Jake, Robert, Marisa, Kasey]
```

keySet and values

- keySet method returns a Set of all keys in the map
  - can loop over the keys in a foreach loop
  - can get each key's associated value by calling get on the map

```
Map<String, Integer> ages = new TreeMap<String, Integer>();
ages.put("Marty", 19);
ages.put("Geneva", 2);  // ages.keySet() returns Set<String>
ages.put("Vicki", 57);
for (String name : ages.keySet()) {              // Geneva -> 2
    int age = ages.get(name);                    // Marty -> 19
    System.out.println(name + " -> " + age);    // Vicki -> 57
}
```

- values method returns a collection of all values in the map
  - can loop over the values in a foreach loop
  - no easy way to get from a value to its associated key(s)

Problem: opposite mapping

- It is legal to have a map of sets, a list of lists, etc.

- Suppose we want to keep track of each TA's GPA by name.

```
Map<String, Double> taGpa = new HashMap<String, Double>();
taGpa.put("Jared", 3.6);
taGpa.put("Alyssa", 4.0);
taGpa.put("Steve", 2.9);
taGpa.put("Stef", 3.6);
taGpa.put("Rob", 2.9);
...
System.out.println("Jared's GPA is " +
                   taGpa.get("Jared"));   // 3.6
```

- This doesn't let us easily ask which TAs got a given GPA.
  - How would we structure a map for that?

Reversing a map

- We can reverse the mapping to be from GPAs to names.

```
Map<Double, String> taGpa = new HashMap<Double, String>();
taGpa.put(3.6, "Jared");
taGpa.put(4.0, "Alyssa");
taGpa.put(2.9, "Steve");
taGpa.put(3.6, "Stef");
taGpa.put(2.9, "Rob");
...
System.out.println("Who got a 3.6? " +
                   taGpa.get(3.6));   // ???
```

- What's wrong with this solution?
  - More than one TA can have the same GPA.
  - The map will store only the last mapping we add.

Proper map reversal

- Really each GPA maps to a *collection* of people.

```
Map<Double, Set<String>> taGpa =
        new HashMap<Double, Set<String>>();
taGpa.put(3.6, new TreeSet<String>());
taGpa.get(3.6).add("Jared");
taGpa.put(4.0, new TreeSet<String>());
taGpa.get(4.0).add("Alyssa");
taGpa.put(2.9, new TreeSet<String>());
taGpa.get(2.9).add("Steve");
taGpa.get(3.6).add("Stef");
taGpa.get(2.9).add("Rob");
...
System.out.println("Who got a 3.6? " +
                   taGpa.get(3.6));   // [Jared, Stef]
```

  - must be careful to initialize the set for a given GPA before adding

Exercises

- Modify the word count program to print every word that appeared in the book at least 1000 times, in sorted order from least to most occurrences.

- Write a program that reads a list of TA names and quarters' experience, then prints the quarters in increasing order of how many TAs have that much experience, along with their names.

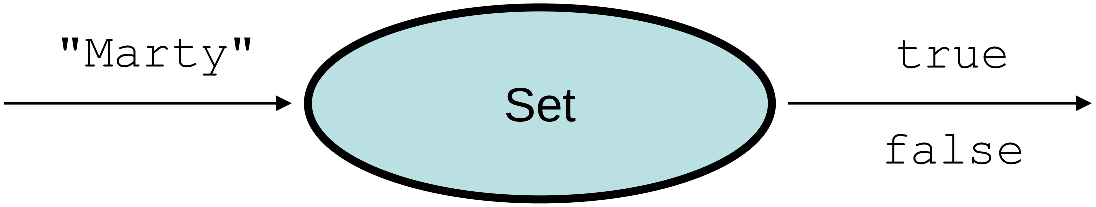
```
Allison 5
Alyssa 8
Brian 1
Kasey 5
...
```

→

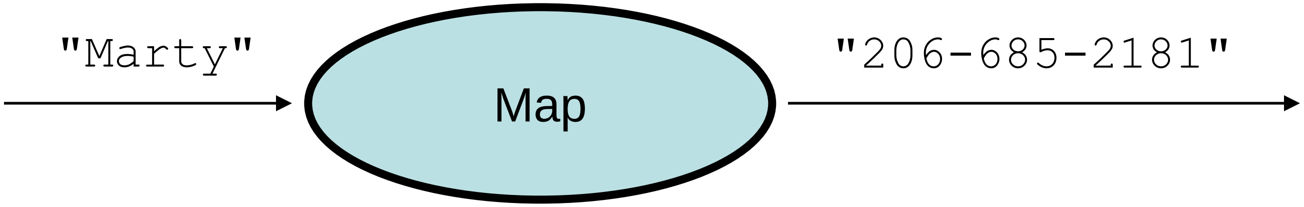
```
1 qtr: [Brian]
2 qtr: ...
5 qtr: [Allison, Kasey]
```

Maps vs. sets

- A set is like a map from elements to `boolean` values.
  - *Set: Is Marty found in the set? (true/false)*



  - *Map: What is Marty's phone number?*



Iterators

reading: 11.1; 15.3; 16.5

Examining sets and maps

- elements of Java `Set`s and `Map`s can't be accessed by index
  - must use a "foreach" loop:

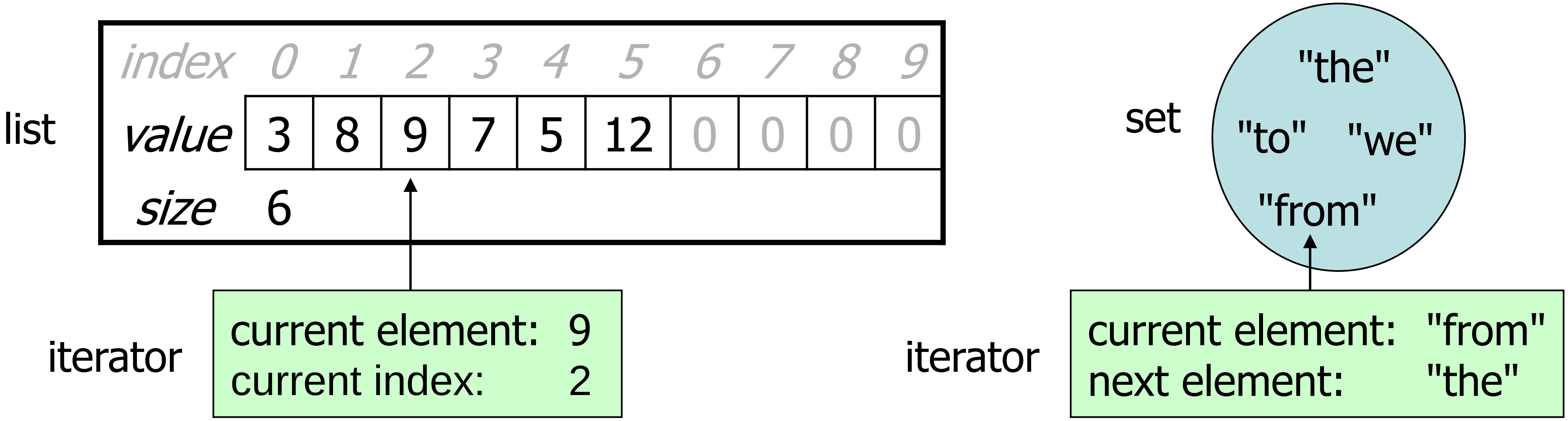
```
Set<Integer> scores = new HashSet<Integer>();
for (int score : scores) {
    System.out.println("The score is " + score);
}
```

  - Problem: foreach is read-only; cannot modify set while looping

```
for (int score : scores) {
    if (score < 60) {
    // throws a ConcurrentModificationException
        scores.remove(score);
    }
}
```

Iterators (11.1)

- **iterator**: An object that allows a client to traverse the elements of any collection.
  - Remembers a position, and lets you:
    - get the element at that position
    - advance to the next position
    - remove the element at that position



list

index	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
value	3	8	9	7	5	12	0	0	0	0
size	6									

iterator

current element: 9
current index: 2

set

iterator

current element: "from"
next element: "the"

Iterator methods

hasNext()	returns true if there are more elements to examine
next()	returns the next element from the collection (throws a NoSuchElementException if there are none left to examine)
remove()	removes the last value returned by next() (throws an IllegalStateException if you haven't called next() yet)

- Iterator interface in java.util
  - every collection has an iterator() method that returns an iterator over its elements

```
Set<String> set = new HashSet<String>();
...
Iterator<String> itr = set.iterator();
...
```

Iterator example

```
Set<Integer> scores = new TreeSet<Integer>();
scores.add(94);
scores.add(38);    // Jenny
scores.add(87);
scores.add(43);    // Marty
scores.add(72);
…

Iterator<Integer> itr = scores.iterator();
while (itr.hasNext()) {
    int score = itr.next();

    System.out.println("The score is " + score);

    // eliminate any failing grades
    if (score < 60) {
        itr.remove();
    }
}
System.out.println(scores);  // [72, 87, 94]
```

Iterator example 2

```
Map<String, Integer> scores = new TreeMap<String, Integer>();
scores.put("Jenny", 38);
scores.put("Stef", 94);
scores.put("Greg", 87);
scores.put("Marty", 43);
scores.put("Angela", 72);
...

Iterator<String> itr = scores.keySet().iterator();
while (itr.hasNext()) {
    String name = itr.next();
    int score = scores.get(name);
    System.out.println(name + " got " + score);

    // eliminate any failing students
    if (score < 60) {
        itr.remove();     // removes name and score
    }
}
System.out.println(scores);  // {Greg=87, Stef=94, Angela=72}
```

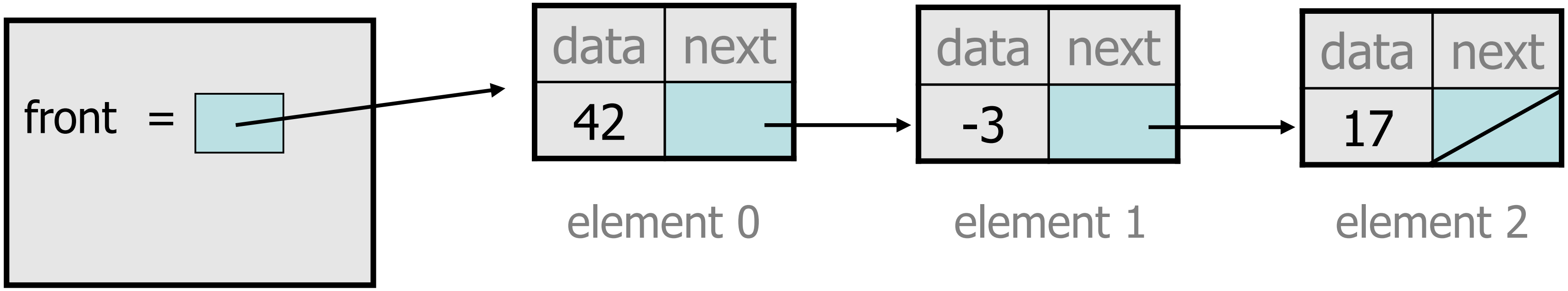
A surprising example

- What's bad about this code?

```
List<Integer> list = new LinkedList<Integer>();
```

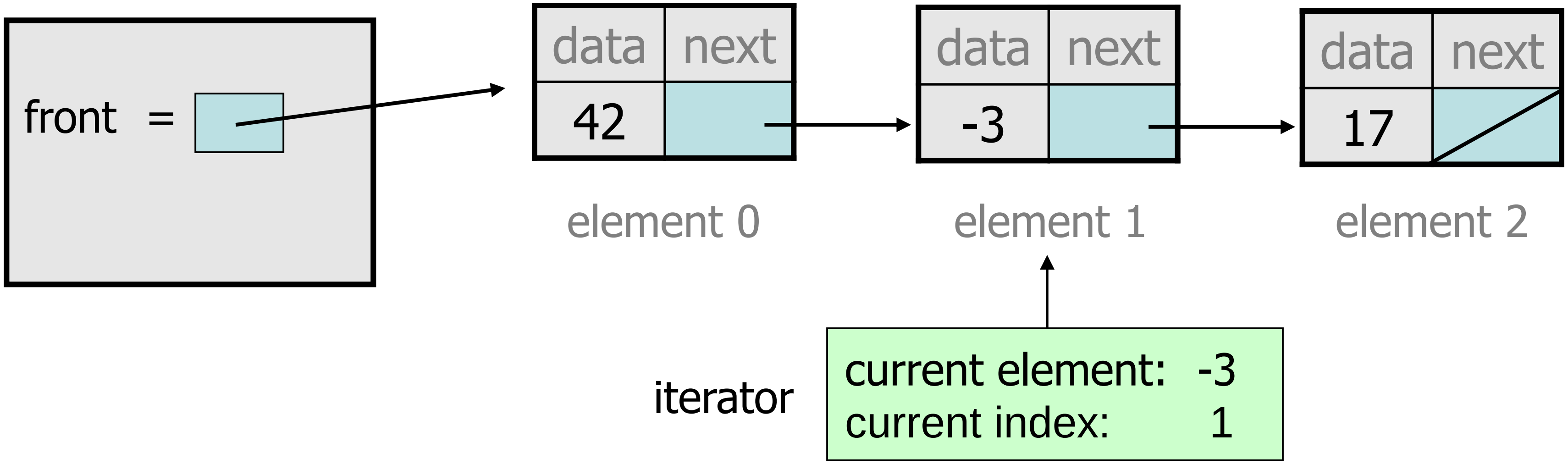
... *(add lots of elements)* ...

```
for (int i = 0; i < list.size(); i++) {
    System.out.println(list.get(i));
}
```



Iterators and linked lists

- Iterators are particularly useful with linked lists.
  - The previous code is O(N^2) because each call on `get` must start from the beginning of the list and walk to index `i`.
  - Using an iterator, the same code is O(N). The iterator remembers its position and doesn't start over each time.



Exercise

- Modify the Book Search program from last lecture to eliminate any words that are plural or all-uppercase from the collection.

- Modify the TA quarters experience program so that it eliminates any TAs with 3 quarters or fewer of experience.

ListIterator

`add(`**`value`**`)`	inserts an element just after the iterator's position
`hasPrevious()`	`true` if there are more elements *before* the iterator
`nextIndex()`	the index of the element that would be returned the next time `next` is called on the iterator
`previousIndex()`	the index of the element that would be returned the next time `previous` is called on the iterator
`previous()`	returns the element before the iterator (throws a `NoSuchElementException` if there are none)
`set(`**`value`**`)`	replaces the element last returned by `next` or `previous` with the given value

```
ListIterator<String> li = myList.listIterator();
```

- lists have a more powerful `ListIterator` with more methods
  - can iterate forwards or backwards
  - can add/set element values (efficient for linked lists)