

# Linked Lists Part 2

Linked List Implementation

Checkout *SinglyLinkedList* project from SVN (Homework)

Checkout `LinkedListSimpleGeneric`

Checkout `CoolPair`

# Let's modify our simple linked list to take arbitrary objects!

- Two ways:
  - Object
  - Generics

# What if we just use object?

```
LinkedList objectList = new LinkedList();  
objectList.addAtBeginning(new Dog("Max", 15));  
objectList.addAtBeginning(new Dog("Sammy", 9));  
objectList.addAtBeginning(new Dog("Gracie", 4));
```

```
System.out.println("Average age is: " +  
getAverageAge(objectList));
```

*Output:* Average age is: 9.3333333333333334

# The problem with Object

```
//But what happens if we add a car to that list?  
objectList.addAtEnd(new Car("Toyota", "Camry"));
```

Java allows us to add a Car to a list of Dogs, because it only knows the Node values are stored as objects

```
System.out.println("Average age is: " + getAverageAge(objectList));
```

## Output:

Exception in thread "main" java.lang.ClassCastException:  
withObject.Car cannot be cast to withObject.Dog

```
public static double getAverageAge(LinkedList objectList) {  
    double totalAge = 0;  
    int count = 0;  
    for (Object o : objectList) {  
        Dog d = (Dog)o;  
        totalAge += d.getAge();  
        count++;  
    }  
    return totalAge/count;  
}
```

This cast is what causes the previous code to fail (when it tries to cast a Car to a Dog). But we must have the cast to get the age field of the Dog objects.

# Generics Prevent Type Errors

```
LinkedList<Dog> dogList = new LinkedList<Dog>();  
dogList.addAtBeginning(new Dog("Max", 15));  
dogList.addAtBeginning(new Dog("Sammy", 9));  
dogList.addAtBeginning(new Dog("Gracie", 4));  
//But what happens if we add a car to that list?  
dogList.addAtEnd(new Car("Toyota", "Camry"));
```

Attempting to insert an object that IS NOT a Dog into the list causes a **compilation** error (better since we'd rather it crash for us and not our clients!).

dogList is declared as a generic list of Dog objects, so only Dog objects (and objects that inherit from Dog) can be put in this list.

```
public static double getAverageAge(LinkedList<Dog> dogList) {  
    double totalAge = 0;  
    int count = 0;  
    for (Dog d : dogList) {  
        totalAge += d.getAge();  
        count++;  
    }  
    return totalAge/count;  
}
```

The enhanced for loop no longer needs a cast, because it knows that the objects in the list are Dog objects. No possibility for a runtime error.

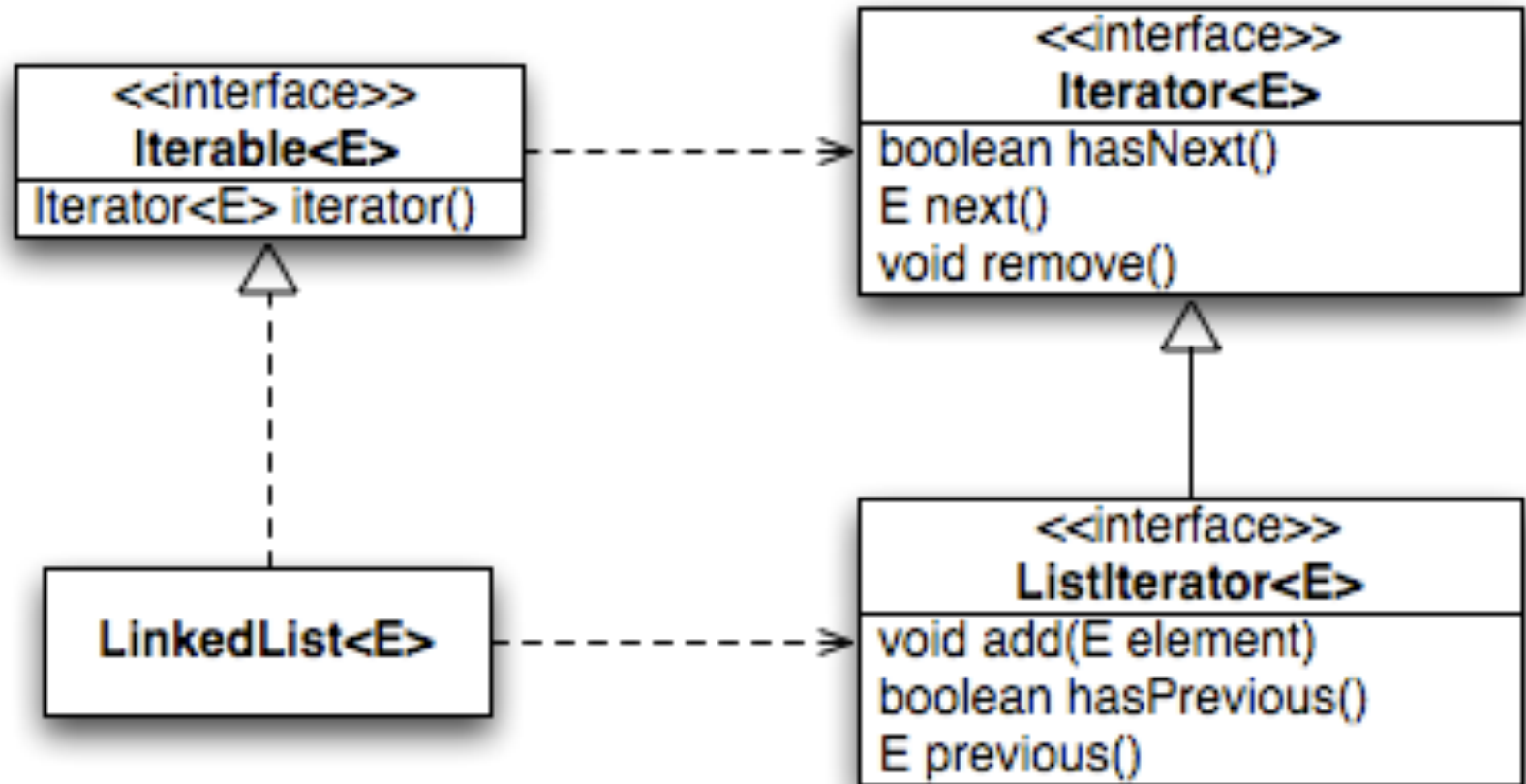
# Generics Advanced

- Type parameters:
  - `class DLList<E>`
- Bounds:
  - `class DLList<E extends Comparable>`
  - `class DLList<E extends Comparable<E>>`
  - `class DLList<E extends Comparable<? super E>>`
- Generic methods:
  - `public static <T> void shuffle(T[ ] array)`
- <http://docs.oracle.com/javase/tutorial/java/generics/index.html>

# What are iterators and why do they exist?

- Iterators are objects designed to encapsulate a position in a data structure – in the case, a pointer to a current (and previous) node in a list
- Your textbook has a detailed discussion of the operation of linked list iterators, including lots of sample code

# Accessing the Middle of a LinkedList





# Why iterators?

They let you write nice for loops!

## Enhanced For Loop

```
for (String s : list) {  
    // do something  
}
```

## What Compiler Generates

```
Iterator<String> iter =  
    list.iterator();  
  
while (iter.hasNext()) {  
    String s = iter.next();  
    // do something  
}
```

# Practice

- Weird warmup: Add an iterator to `CoolPair<T>`
  - Weird: why iterate over a Pair? Oh well.
- Make `LinkedListGeneric` generic and add an iterator to it. Notes:
  - T could be any object. So will need to change `==` to `.equals()` when comparing things of type T.
    - But still use `==` for Nodes: `if (this.current == null) { ...}`
  - When adding `<Integer>` to tests, also need to change the `int[]` array passed in to `Integer[]` to match.
  - You can test your iterator using a `foreach` loop in main
  - Get help! This is practice for the next assignment.

# Homework:

## Implementing SinglyLinkedList

- Just a step up from the ones we've written, but more focused on implementing the essentials from the `java.util.List` interface
- Will have the usual linked list behavior
  - Fast insertion and removal of elements
    - Once we know where they go using an iterator
  - Slow random access

**TEAM PROJECT WORK TIME**