

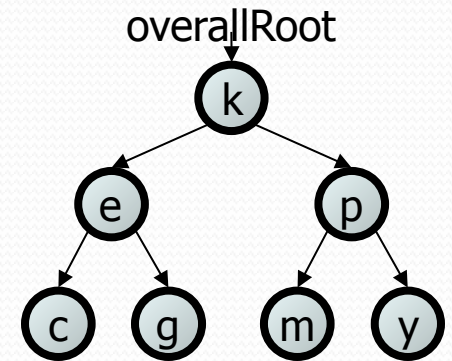
Building Java Programs

Inner classes, generics, abstract classes

reading: 9.6, 15.4, 16.4-16.5

A tree set

- Our `SearchTree` class is essentially a set.
 - operations: `add`, `remove`, `contains`, `size`, `isEmpty`
 - similar to the `TreeSet` class in `java.util`
- Let's actually turn it into a full set implementation.
 - *step 1*: create ADT interface; implement it
 - *step 2*: get rid of separate node class file
 - *step 3*: make tree capable of storing any type of data (not just `int`)
- We won't rebalance the tree, take a data structures class to learn how!



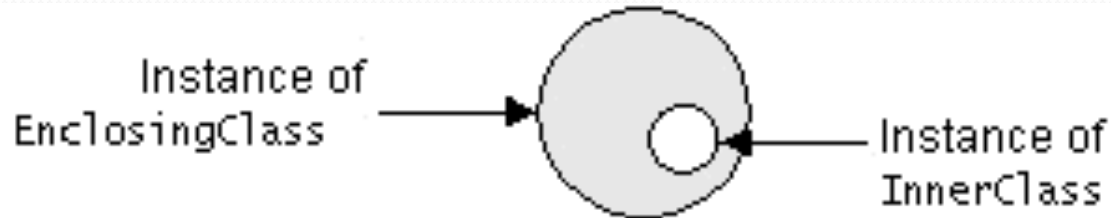
Recall: ADTs (11.1)

- **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 ADTs with interfaces:
 - `Collection`, `Deque`, `List`, `Map`, `Queue`, `Set`, `SortedMap`
- An ADT can be implemented in multiple ways by classes:
 - `ArrayList` and `LinkedList` `implement List`
 - `HashSet` and `TreeSet` `implement Set`
 - `LinkedList` , `ArrayDeque`, etc. `implement Queue`

Inner classes

To get rid of our separate node file, we use an *inner class*.

- **inner class:** A class defined inside of another class.
 - inner classes are hidden from other classes (encapsulated)
 - inner objects can access/modify the fields of the outer object



Inner class syntax

```
// outer (enclosing) class
public class name {
    ...

    // inner (nested) class
    private class name {
        ...
    }
}
```

- Only this file can see the inner class or make objects of it.
- Each inner object is associated with the outer object that created it, so it can access/modify that outer object's methods/fields.
 - If necessary, can refer to outer object as **OuterClassName.this**

Recall: Type Parameters

```
ArrayList<Type> name = new ArrayList<Type>();
```

- When constructing a `java.util.ArrayList`, you specify the type of elements it will contain in `<` and `>`.
 - `ArrayList` accepts a **type parameter**; it is a **generic** class.

```
ArrayList<String> names = new ArrayList<String>();  
names.add("Marty Stepp");  
names.add("Helene Martin");  
names.add(42); // compiler error
```

Implementing generics

```
// a parameterized (generic) class
public class name<Type> {
    ...
}
```

- Forces any client that constructs your object to supply a type.
 - Don't write an actual type such as String; the client does that.
 - Instead, write a type variable name such as E (for "element") or T (for "type").
 - You can require multiple type parameters separated by commas.
- The rest of your class's code can refer to that type by name.

Generics and inner classes

```
public class Foo<E> {  
    private class Inner<E> {...}    // incorrect  
    private class Inner {...}      // correct  
}
```

- If an outer class declares a type parameter, inner classes can also use that type parameter.
- The inner class should NOT redeclare the type parameter.
 - (If you do, it will create a second type param with the same name.)

Issues with generic objects

```
public class TreeSet<E> {  
    ...  
    public void example(E value1, E value2) {  
        // BAD: value1 == value2      (they are objects)  
        // GOOD: value1.equals(value2)  
  
        // BAD: value1 < value2  
        // GOOD: value1.compareTo(value2) < 0  
    }  
}
```

- When testing objects of type `E` for equality, must use `equals`
- When testing objects of type `E` for `<` or `>`, must use `compareTo`
 - Problem: By default, `compareTo` doesn't compile! What's wrong!

Type constraints

```
// a parameterized (generic) class
public class name<Type extends Class/Interface> {
    ...
}
```

- A **type constraint** forces the client to supply a type that is a subclass of a given superclass or implements a given interface.
 - Then the rest of your code can assume that the type has all of the methods in that superclass / interface and can call them.

Generic set interface

```
// Represents a list of values.
```

```
public interface Set<E> {  
    public void add(E value);  
    public boolean isEmpty();  
    public boolean contains(E value);  
    public void remove(E value);  
    public int size();  
}
```

```
public class TreeSet<E extends Comparable<E>>  
    implements Set<E> {  
    ...  
}
```

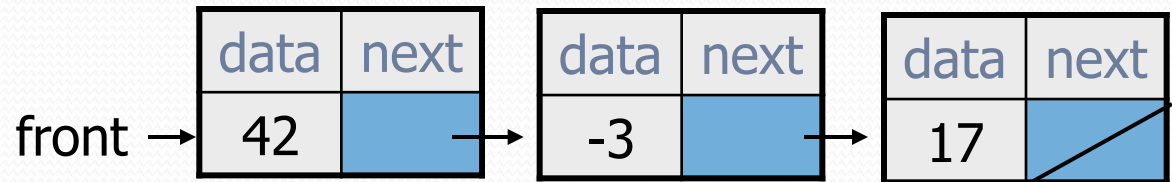
Our list classes

- We have implemented the following two list collection classes:

- `ArrayIntList`

index	0	1	2
value	42	-3	17

- `LinkedIntList`



- Problems:

- We should be able to treat them the same way in client code.
- Linked list carries around a clunky extra node class.
- They can store only `int` elements, not any type of value.
- **Some methods are implemented the same way (redundancy).**
- It is inefficient to get or remove each element of a linked list.

Generics and arrays (15.4)

```
public class Foo<T> {  
    private T myField; // ok  
  
    public void method1(T param) {  
        myField = new T(); // error  
        T[] a = new T[10]; // error  
  
        myField = param; // ok  
        T[] a2 = (T[]) (new Object[10]); // ok  
    }  
}
```

- You cannot create objects or arrays of a parameterized type.
- You can create variables of that type, accept them as parameters, return them, or create arrays by casting from `Object[]`.

Common code

- Notice that some of the methods are implemented the same way in both the array and linked list classes.
 - `add(value)`
 - `contains`
 - `isEmpty`
- Should we change our interface to a class? Why / why not?
 - How can we capture this common behavior?

Abstract classes (9.6)

- **abstract class:** A hybrid between an interface and a class.
 - defines a superclass type that can contain method declarations (like an interface) and/or method bodies (like a class)
 - like interfaces, abstract classes that cannot be instantiated (cannot use `new` to create any objects of their type)
- What goes in an abstract class?
 - implementation of common state and behavior that will be inherited by subclasses (parent class role)
 - declare generic behaviors that subclasses must implement (interface role)

Abstract class syntax

```
// declaring an abstract class
public abstract class name {
    ...
    // declaring an abstract method
    // (any subclass must implement it)
    public abstract type name(parameters);
}
```

- A class can be `abstract` even if it has no abstract methods
- You can create variables (but not objects) of the abstract type
- Exercise: Introduce an abstract class into the list hierarchy.

Abstract and interfaces

- Normal classes that claim to implement an interface must implement all methods of that interface:

```
public class Empty implements IntList {} // error
```

- Abstract classes can claim to implement an interface without writing its methods; subclasses must implement the methods.

```
public abstract class Empty implements IntList {} //  
ok
```

```
public class Child extends Empty {} // error
```

An abstract list class

```
// Superclass with common code for a list of integers.
public abstract class AbstractIntList implements IntList {
    public void add(int value) {
        add(size(), value);
    }

    public boolean contains(int value) {
        return indexOf(value) >= 0;
    }

    public boolean isEmpty() {
        return size() == 0;
    }
}
```

```
public class ArrayIntList extends AbstractIntList { ...
public class LinkedIntList extends AbstractIntList { ...
```

Abstract class vs. interface

- Why do both interfaces and abstract classes exist in Java?
 - An abstract class can do everything an interface can do and more.
 - So why would someone ever use an interface?
- Answer: Java has single inheritance.
 - can extend only one superclass
 - can implement many interfaces
 - Having interfaces allows a class to be part of a hierarchy (polymorphism) without using up its inheritance relationship.

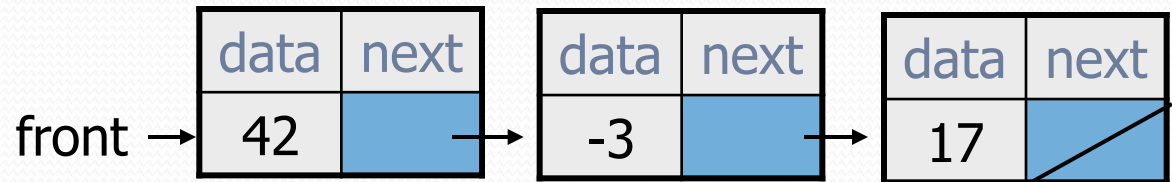
Our list classes

- We have implemented the following two list collection classes:

- `ArrayIntList`

index	0	1	2
value	42	-3	17

- `LinkedIntList`



- Problems:

- We should be able to treat them the same way in client code.
- Linked list carries around a clunky extra node class.
- They can store only `int` elements, not any type of value.
- Some of their methods are implemented the same way (redundancy).
- **It is inefficient to get or remove elements of a linked list.**