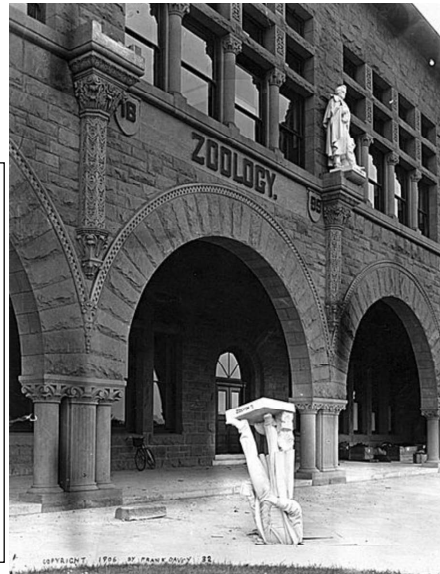


Topic 9

Abstract Classes

“I prefer Agassiz in the abstract, rather than in the concrete.”

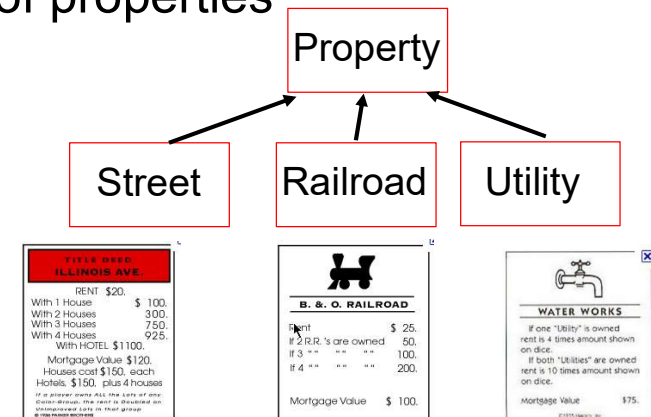
- Statue of Biologist Louis Agassiz that fell from a ledge on the Stanford Quad during the 1906 San Francisco earthquake.



1

Back to the Monopoly Property Example

- There are properties on a monopoly board
- Railroads, Utilities, and Streets are kinds of properties



A getRent Behavior

- One behavior we want in Property is the getRent method
- problem: How do I get the rent of something that is “just a Property”?

The Property class

```
public class Property {  
  
    private int cost;  
    private String name;  
  
    public int getRent() {  
        return hmmmmm??????;  
    }  
}
```

Doesn't seem like we have enough information to get the rent if all we know is it is a Property.

Potential Solutions

1. Just leave it for the sub classes.
 - Have each sub class define getRent()
2. Define getRent() in Property and simply return -1.
 - Sub classes override the method with more meaningful behavior.

Leave it to the Sub - Classes

```
// no getRent() in Property
// Railroad and Utility DO have getRent() methods

public void printRents(Property[] props) {
    for (Property p : props)
        System.out.println(p.getRent());
}

Property[] props = new Property[2];
props[0] = new Railroad("NP", 200, 1);
props[1] = new Utility("Electric", 150, false);
printRents(props);
```

Clicker 1 - What is result of above code?

- | | |
|---------------------------|-------------------------|
| A. 200150 | B. different every time |
| C. Syntax error | D. Class Cast Exception |
| E. Null Pointer Exception | |

"Fix" by Casting

```
// no getRent() in Property
public void printRents(Property[] props) {
    for (Property p : props) {
        if (p instanceof Railroad)
            System.out.println(((Railroad) p).getRent());
        else if (p instanceof Utility)
            System.out.println(((Utility) p).getRent());
        else if (p instanceof Street)
            System.out.println(((Street) p).getRent());
    } // GACK!!!!
}

Property[] props= new Property[2];
props[0] = new Railroad("NP", 200, 1);
props[1] = new Utility("Electric", 150, false);
printRents( props);
```

What happens as we add more sub classes of Property?

What happens if one of the objects is just a Property?

Fix with Placeholder Return

```
// getRent() in Property returns -1

public void printRents(Property[] props) {
    for (Property p : props)
        System.out.println(p.getRent());
}

Property[] props= new Property[2];
props[0] = new Railroad("NP", 200, 1);
props[1] = new Utility("Electric", 150, false);
printRents(props);
```

What happens if sub classes don't override getRent()?

Is that a good answer?

A Better Fix

- ▶ We know we want to be able to get the rent of objects that are instances of `Property`
- ▶ The problem is we don't know how to do that if all we know is it a `Property`
- ▶ Make `getRent` an abstract method
- ▶ Java keyword

Making `getRent` Abstract

```
public class Property {  
  
    private int cost;  
    private String name;  
  
    public abstract int getRent();  
    // I know I want it.  
    // Just don't know how, yet...  
  
}
```

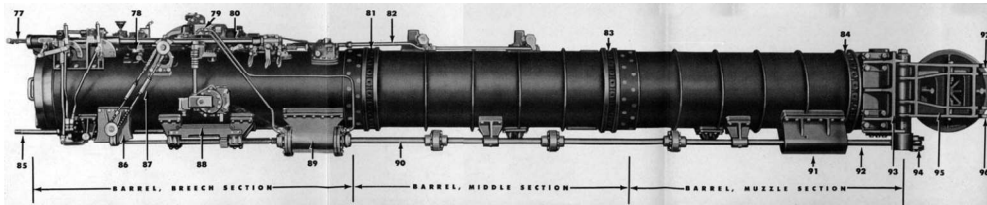
Methods that are declared abstract have no body an undefined behavior.

All non-default methods in a Java interface are abstract.

Problems with Abstract Methods

Given `getRent()` is now an abstract method what is wrong with the following code?

```
Property p = new Property();  
System.out.println(p.getRent());
```



If things can go wrong with a tool, provide safeguards to prevent that from happening.

Undefined Behavior = Bad

- ▶ Not good to have undefined behaviors
- ▶ If a class has 1 or more abstract methods, the class must also be declared abstract.
 - version of `Property` shown would cause a compile error
- ▶ Even if a class has zero abstract methods a programmer can still choose to make it abstract
 - if it models some abstract thing
 - is there anything that is just a “Mammal”?

Abstract Classes Safety

1. A class with one or more abstract methods must be declared abstract.
 - Syntax error if not done.
 - Can still decide to make class abstract even if no abstract methods.
2. Objects of an abstract type cannot be instantiated.
 - Just like interfaces
 - Can still declare variables of this type
3. A subclass must implement all inherited abstract methods or be abstract itself.

Abstract Classes

```
public abstract class Property {  
  
    private int cost;  
    private String name;  
  
    public abstract double getRent();  
    // I know I want it.  
    // Just don't know how, yet...  
  
}  
// Other methods not shown
```

if a class is abstract the compiler will not allow constructors of that class to be called

```
Property s = new Property(1, 2);  
//syntax error
```

Abstract Classes

- In other words you can't create instances of objects where the lowest or most specific class type is an abstract class
- Prevents having an object with an undefined behavior
- Why would you still want to have constructors in an abstract class?
- Object variables of classes that are abstract types may still be declared

```
Property p; //okay
```

Sub Classes of Abstract Classes

- Classes that extend an abstract class must provided a working version of any and all abstract methods from the parent class
 - or they must be declared to be abstract as well
 - could still decide to keep a class abstract regardless of status of abstract methods

Implementing getRent()

```
public class Railroad extends Property {  
    private static int[] rents  
        = {25, 50, 100, 200};  
  
    private int numOtherRailroadsOwned;  
  
    public double getRent() {  
        return rents[numOtherRailroadsOwned];  
    }  
  
    // other methods not shown  
}
```

A Utility Class

```
public class Utility extends Property {  
  
    private static final int ONE_UTILITY_RENT = 4;  
    private static final int TWO_UTILITY_RENT = 10;  
  
    private boolean ownOtherUtility;  
  
    public Utility(String n, int c, boolean other) {  
        super(n, c);  
    }  
  
    public String toString() {  
        return "Utility. own other utility? " + ownOtherUtility;  
    }  
  
    public int getRent(int roll) {  
        return ownOtherUtility ? roll * TWO_UTILITY_RENT :  
            roll * TWO_UTILITY_RENT;  
    }  
}
```

Polymorphism in Action

```
// getRent() in Property is abstract  
  
public void printRents(Property[] props) {  
    for (Property p : props)  
        System.out.println(p.getRent());  
}
```

- Add the Street class. What needs to change in printRents method?
- Inheritance is can be described as new code using old code.
- **Koan of Polymorphism: Polymorphism can be described as old code reusing new code.**

Comparable in Property

```
public abstract class Property  
    implements Comparable<Property> {  
  
    private int cost;  
    private String name;  
  
    public abstract int getRent();  
  
    public int compareTo(Property other) {  
        return this.getRent()  
            - otherProperty.getRent();  
    }  
}
```

Back to Lists

- We suggested having a list interface

```
public interface IList<E> extends Iterable<E> {  
    public void add(E value);  
    public int size();  
    public E get(int location);  
    public E remove(int location);  
    public boolean contains(E value);  
    public void addAll(IList<E> other);  
    public boolean containsAll(IList<E> other);  
}
```

Data Structures

When implementing data structures:

- Specify an interface
- Create an abstract class that is *skeletal implementation* interface
- Create classes that extend the skeletal interface

```
public boolean contains(E val) {  
    for (E e : this)  
        if val.equals(e)  
            return true;  
    return false
```