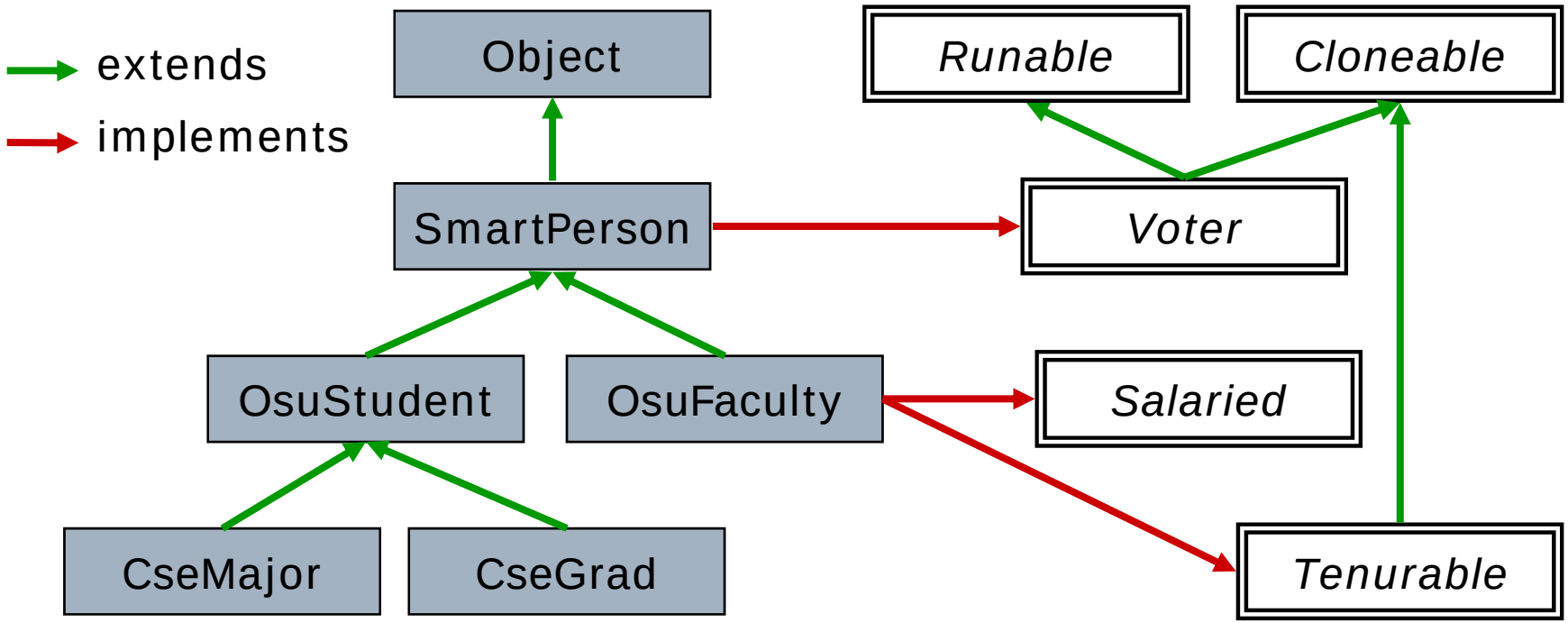
Inheritance: Applications and Consequences

Lecture 13

Class and Interface Hierarchies



OsuFaculty extends SmartPerson, Object
OsuFaculty implements Salaried, Tenurable, Voter, Runable, Cloneable

Abstract Classes

- A class can be declared to be *abstract*

```
abstract class Design { . . . }
```

  - Can not be instantiated (same as interfaces)
  - May contain *abstract methods*
- An *abstract method* has no implementation

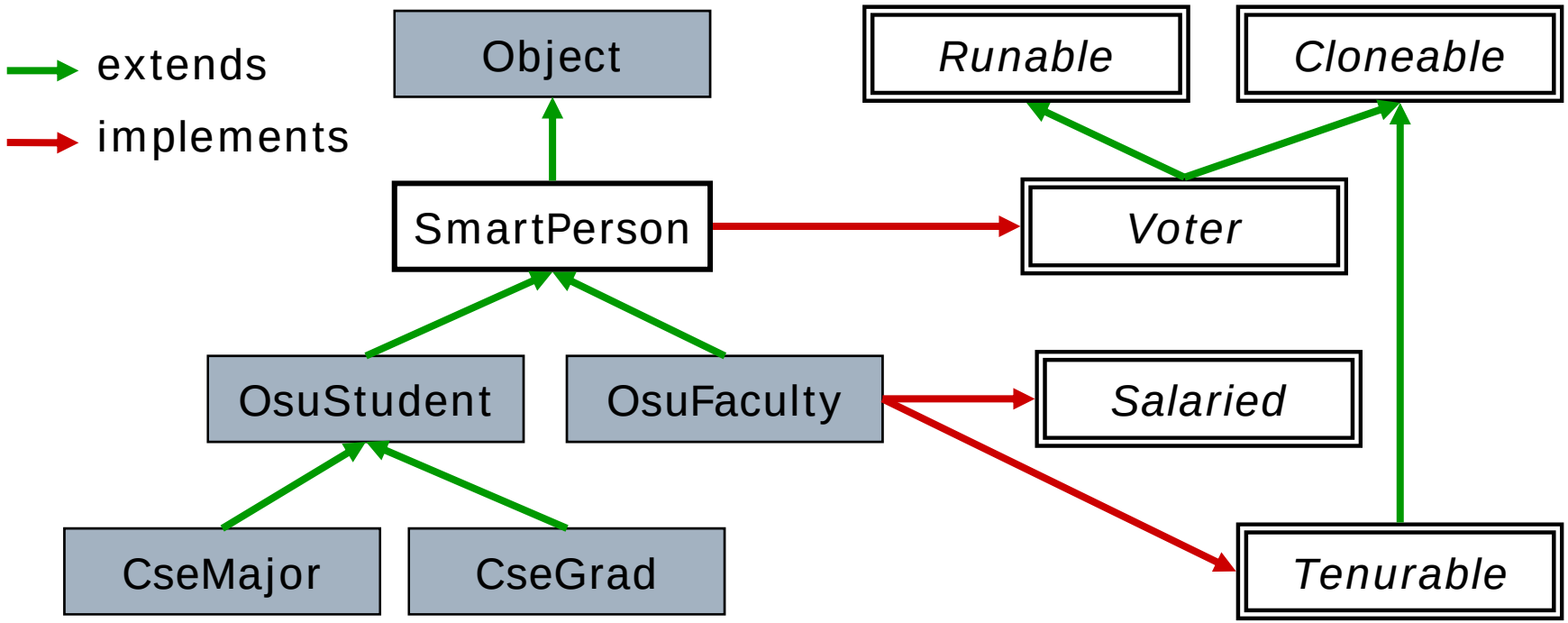
```
abstract class Design {
  void setLabel() { . . . }
  abstract int getCost();
}
```

- Only a subclass that implements all of these abstract methods can be instantiated

```
class Drawing extends Design {
  @Override int getCost() { . . . }
}
```

  - Otherwise, the subclass is abstract too
- Combination of interface and class

Class and Interface Hierarchies



Instantiable?

Yes: Object, OsuStudent, OsuFaculty, CseMajor, CseGrad

No : SmartPerson, Runable, Clonable, Voter, Salaried, Tenurable

Abstract Classes vs. Interfaces

- Similarities
  - Neither can be instantiated
- Differences
  - Abstract classes permit:
    - Constructors
    - Static methods
    - Fields (but these are not part of public interface anyway, right?)
    - Visibilities: private/protected/default/public
    - Implementations
  - Interfaces permit:
    - Multiple inheritance

Controlling Inheritance: final

- Ultimate control: disallow
  - Declare class to be final

```
final class CseMajor { ... }
```

  - Abstract classes can not be final

```
final abstract class SmartPerson { ... }
```

- Finer granularity: Disallow certain methods to be overridden
  - Declare method to be final

```
abstract class SmartPerson {
  final int getAge() { . . . }
```

  - Permitted in abstract classes, but an abstract method can not be final
  - unlike C++ (explicitly permit overriding with *virtual*)

Hook and Template Methods

- Recall pattern:
  - Base class contains both template and hook methods
  - Template method calls this.hook method
  - Hook methods are overridden in derived classes
  - Template method is not
- To support this pattern:
  - Template method is declared final
  - Hook methods are declared abstract
    - So base class declared abstract too
  - Hook methods are declared protected
- See divide-and-conquer example
  - solve() is the template method

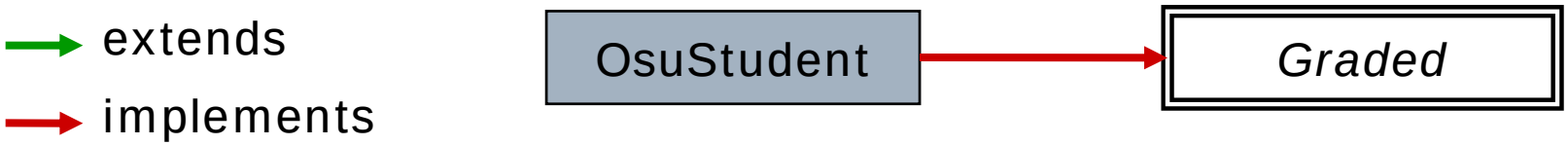
Hook and Template Idiom

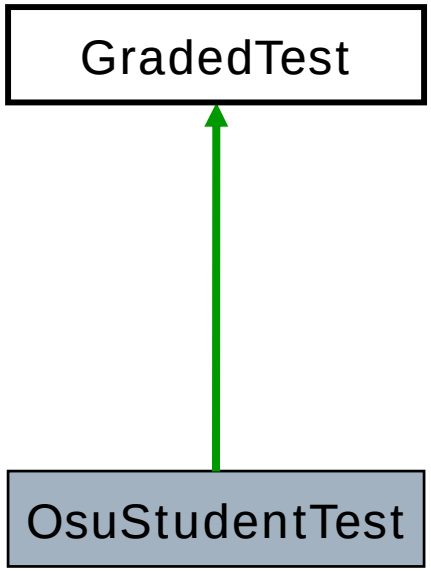

```
public abstract class Course {
  public final void enroll(Student s) {
    if (checkEligibility(s)) { … }
  }
  protected abstract boolean
    checkEligibility(Student s);
}

public class Tutorial extends Course {
  @Override
  protected boolean
    checkEligibility(Student s) {
      //determines whether s has paid
  }
}
```

JUnit Pattern

- Goal: Separate interface and implementation tests
  - Former are based on abstract client-side view
  - Latter based on concrete implementers view
- Approach:
  - Test fixture for interface tests is a base class
  - Test fixture for implementation tests extends it
- JUnit tests require an object (class instance)
  - In base class:
    - Use protected member(s) of interface type
    - abstract @Before method
  - In derived class:
    - Override @Before method to instantiate class and initialize the protected member(s)
- See RandomWithParity example

JUnit with Inheritance






```
protected Graded g;
@Before
public abstract void setUp();
@Test
public void someTest1() {...}
@Test
public void someTest2() {...}
```

```
@Override @Before
public void setUp() {
  g = new OsuStudent();
}
```

Limitations of This JUnit Pattern

- Limitation 1: Single inheritance
  - If interface A extends B, no problem: test fixture ATest simply extends test fixture BTest!
  - But interface A extends B, C is trouble
  - Reason: with classes we are limited to single inheritance
- Limitation 2: Complex construction
  - Assumes test cases do not require a particular constructor call for the class under test (all use default constructor)
  - What if this is not the case? (eg BigNatural)
  - Solution: Factory methods (We'll see these later)

Javadoc

- Javadoc comments (main description, @param, @return) are implicitly inherited when omitted for a method
  - In a class that overrides a method in superclass
  - In an interface that overrides a method in superinterface
  - In a class that implements a method in interface
- Javadoc generates “Overrides” block for first two, and “Specified by” block for last one
  - Links to comment for that parent method
- {@inheritDoc} explicitly inherits parent’s comment
  - Replaced by text of parent’s comment; can add text around it to augment with specifics of child
  - Use in main description, @param, @return

Narrowing

- Recall that narrowing requires explicit cast
  - Programmer promise that this is OK

```
void v(OsuStudent s) {
  (CseMajor)s.assignJavaLab();
}
```

- What if the programmer is wrong?
  - Results in run-time failure (an “exception”)
- Programmer can check first if it is OK
  - Operator: *instanceof*

```
if (v instanceof BankAccount) {
  (BankAccount)v.deposit();
    . . .
```

- Beware:
  - Any use of *instanceof* in code is a red flag
  - Especially bad smell: switch() based on *instanceof*

Surprise?

- Static methods are inherited
- But, they do *not* get polymorphic run-time selection
  - Implementation selected according to *declared type*
  - Yet another reason to invoke static methods through class (not an instance)

Example


```
public class Base {
  public static int f() {
    return 4;
  }
}
public class Derived extends Base {
  public static int f() {
    return 8;
  }
}
…
  Base b = new Derived();
  System.out.println(b.f());
  //What does this print?
```

Good Practice: Static Members

- Do *not* access static members through object references
- Use class names instead
  - Do this: `int t = Pencil.defaultLength;`
  - Not this: `int t = p1.defaultLength;`
- This applies within a class too

```
class Pencil {
  private static int defaultLength = 10;
  private int length;
  public void reset() {
    length = defaultLength;         //correct
    length = Pencil.defaultLength; //better
  }
}
```

Better Version


```
public class Base {
  public static int f() {
    return 4;
  }
}
public class Derived extends Base {
  public static int f() {
    return 8;
  }
}
…
  System.out.println(Base.f());
  System.out.println(Derived.f());
  //What does this print?
```

Inheritance Myths

- class A extends B implies A is a behavioral subtype of B
- No! Overriding methods could break everything

Inheritance Myths

- If I don't override any methods, everything is fine
- No! Adding new methods could break the invariant!

Summary

- Abstract classes
  - Contain abstract methods
  - Missing some implementation
  - Like interfaces, can not be instantiated
- Final methods
  - Can prevent overriding specific methods
- Template and hook pattern
  - Template class and hook methods all abstract
  - Template method is final
- Leveraging inheritance for JUnit
- Javadoc features
- Static methods can not be overridden
- Inheritance myths