# CSE 331
# Software Design & Implementation

Spring 2021

Section10: Review + Design Patterns

# Administrivia

- HW9 due tomorrow (Fri. 6/4 @ 11:00pm)
- Final Exam next week

# Final Exam

- Monday morning – Tuesday evening or so
- Gradescope timed exam
- 90-120 (TBD) minutes time limit
- Will be open for about ~36 hours to take
- Multiple versions
- You will have to find the version assigned to you in a spreadsheet that we will send out
- Open notes
- Contact us ASAP if there are problems
- Visit courses.cs.washington.edu/courses/cse331/21sp/exam.html for more info
- Any questions?

# Agenda

- Review

  Reasoning, Specifications, ADTs (RI & AF), Testing, Defensive Programming, Equals and Hash Code, Exceptions, Subtyping, Generics

- Design Patterns

# Stronger vs Weaker (one more time!)

In each case, what is the effect of changing the amount of information required about the input?

- Requires more about inputs?

- Promises more about behavior?

# Stronger vs Weaker (one more time!)

- Requires more about inputs?

  **weaker**

- Promises more about behavior?

  **stronger**

# Stronger vs Weaker

Compared to the spec in the box, what is the effect of using specs A,B,C in terms of our statement's strength (weaker/stronger/neither)?

```
@requires key is a key in this
@return the value associated with key
@throws NullPointerException if key is null
```

```
A.@requires that key is a key in this and key != null
    @return the value associated with key

B.@return the value associated with key if key is a
        key in this, or null if key is not associated
        with any value

C.@return the value associated with key
    @throws NullPointerException if key is null
    @throws NoSuchElementException if key is not a
            key this
```

# Stronger vs Weaker

```
@requires key is a key in this
@return the value associated with key
@throws NullPointerException if key is null
```

A.
```
@requires key is a key in this and key != null
  @return the value associated with key
```
**WEAKER**

B.
```
@return the value associated with key if key is a
      key in this, or null if key is not associated
      with any value
```
**NEITHER**

C.
```
@return the value associated with key
  @throws NullPointerException if key is null
  @throws NoSuchElementException if key is not a
          key this
```
**STRONGER**

# Exceptions

- Unchecked exceptions are ignored by the compiler.
- If a method throws a checked exception or calls a method that throws a checked exception, then it must either:
  - catch the exception
  - declare it in `@throws`

# Exceptions Examples

Should these be checked or unchecked?

- Attempt to write an invalid type into an array
  E.g., write `Double` into `Integer[]` cast to `Number[]`

- Attempt to open a file that does not exist

- Attempt to create a URL from invalidly formatted text
  E.g., “http:/foo” (only one “/”)

# Exceptions Examples

Should these be checked or unchecked?

- Attempt to write an invalid type into an array
  E.g., write `Double` into `Integer[]` cast to `Number[]`
  **unchecked**

- Attempt to open a file that does not exist
  **checked**

- Attempt to create a URL from invalidly formatted text
  E.g., "http:/foo" (only one "/")
  **debatable** – could see either one

# Subtypes & Subclasses

- Subtypes are substitutable for supertypes
- If `Foo` is a subtype of `Bar`,
  `G<Foo>` is a **NOT** a subtype of `G<Bar>`
  - Aliasing resulting from this would let you add objects of type `Bar` to `G<Foo>`, which would be bad!
  - Example:

```
List<String> ls = new ArrayList<String>();
List<Object> lo = ls;
lo.add(new Object());
String s = ls.get(0);
```

- Subclassing is done to reuse code (extends)
  - A subclass can override methods in its superclass

# Typing and Generics

- <?> is a wildcard for unknown
  - Upper bounded wildcard: type is wildcard or subclass
    - Eg: `List<? extends Shape>`
    - Safe to read from: result will be a `Shape`
    - Illegal to write into (no calls to add!) because we can't guarantee type safety.
  - Lower bounded wildcard: type is wildcard or superclass
    - Eg: `List<? super Integer>`
    - May be safe to write into.
    - Illegal to retrieve as type other than `Object`.

# Subtypes & Subclasses

```
class Student extends Object { ... }
class CSEStudent extends Student { ... }
```

```
List<Student> ls;
List<? extends Student> les;
List<? super Student> lss;
List<CSEStudent> lcse;
List<? extends CSEStudent> lecse;
List<? super CSEStudent> lscse;
Student scholar;
CSEStudent hacker;
```

ls = lcse;

les = lscse;

lcse = lscse;

les.add(scholar);

lscse.add(scholar);

lss.add(hacker);

scholar = lscse.get(0);

hacker = lecse.get(0);

# Subtypes & Subclasses

```
class Student extends Object { ... }
class CSEStudent extends Student { ... }
```

```
List<Student> ls;
List<? extends Student> les;
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List<CSEStudent> lcse;
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Student scholar;
CSEStudent hacker;
```

ls = lcse; **X**

les = lscse;

lcse = lscse;

les.add(scholar);

lscse.add(scholar);

lss.add(hacker);

scholar = lscse.get(0);

hacker = lecse.get(0);

# Subtypes & Subclasses

```
class Student extends Object { ... }
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ls = lcse; **X**

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ls = lcse; **X**

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# Subtypes & Subclasses

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class Student extends Object { ... }
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Student scholar;
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```

ls = lcse; X

les = lscse; X

lcse = lscse; X

les.add(scholar); X

lscse.add(scholar);

lss.add(hacker);

scholar = lscse.get(0);

hacker = lecse.get(0);

# Subtypes & Subclasses

Given the below classes which one of the statements in the box are legal?

```
class Student extends Object { ... }
class CSEStudent extends Student { ... }
```

```
List<Student> ls;
List<? extends Student> les;
List<? super Student> lss;
List<CSEStudent> lcse;
List<? extends CSEStudent> lecse;
List<? super CSEStudent> lscse;
Student scholar;
CSEStudent hacker;
```

ls = lcse; X

les = lscse; X

lcse = lscse; X

les.add(scholar); X

lscse.add(scholar); X

lss.add(hacker);

scholar = lscse.get(0);

hacker = lecse.get(0);

# Subtypes & Subclasses

```
class Student extends Object { ... }
class CSEStudent extends Student { ... }
```

```
List<Student> ls;
List<? extends Student> les;
List<? super Student> lss;
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List<? extends CSEStudent> lecse;
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Student scholar;
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ls = lcse; X

les = lscse; X

lcse = lscse; X

les.add(scholar); X

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scholar = lscse.get(0);

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# Subtypes & Subclasses

```
class Student extends Object { ... }
class CSEStudent extends Student { ... }
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ls = lcse; X

les = lscse; X

lcse = lscse; X

les.add(scholar); X

lscse.add(scholar); X

lss.add(hacker); 

scholar = lscse.get(0); X

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# Subtypes & Subclasses

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class Student extends Object { ... }
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List<CSEStudent> lcse;
List<? extends CSEStudent> lecse;
List<? super CSEStudent> lscse;
Student scholar;
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```

ls = lcse; X

les = lscse; X

lcse = lscse; X

les.add(scholar); X

lscse.add(scholar); X

lss.add(hacker); 

scholar = lscse.get(0); X

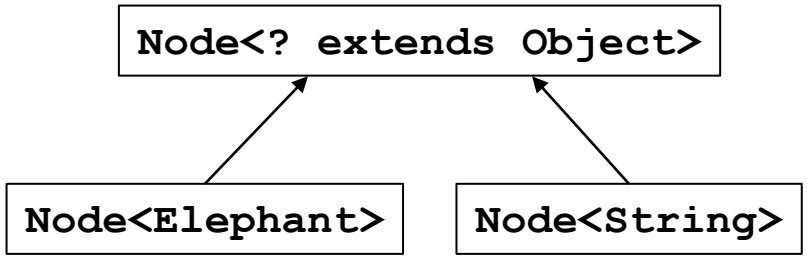
hacker = lecse.get(0); 

# **equals** for a parameterized class

```
class Node<E> {
  …
  @Override
  public boolean equals(Object obj) {
    if (!(obj instanceof Node<?>)) {
      return false;
    }
    Node<?> n = (Node<?>) obj;
    return this.data().equals(n.data());
  }
  …
}
```

Works if the type of obj is **Node<Elephant>** or **Node<String>** or …

Leave it to here to "do the right thing" if **this** and **n** differ on element type



# Subclasses & Overriding

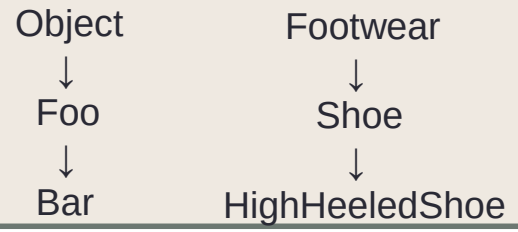
```
class Foo extends Object {
     Shoe m(Shoe x, Shoe y){ ... }
}

class Bar extends Foo {...}
```

# Method Declarations in Bar

Given the class in the purple box, determine whether the method declarations for the method Shoe() inside Bar class are overriding or overloading it?

- The result is method overriding
- The result is method overloading
- The result is a type-error
- None of the above



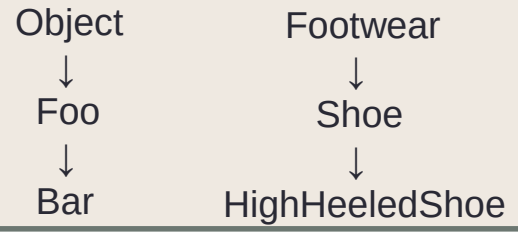

- FootWear m(Shoe x, Shoe y) { ... }
- Shoe m(Shoe q, Shoe z) { ... }
- HighHeeledShoe m(Shoe x, Shoe y) { ... }
- Shoe m(FootWear x, HighHeeledShoe y) { ... }
- Shoe m(FootWear x, FootWear y) { ... }
- Shoe m(Shoe x, Shoe y) { ... }
- Shoe m(HighHeeledShoe x, HighHeeledShoe y) { ... }
- Shoe m(Shoe y) { ... }
- Shoe z(Shoe x, Shoe y) { ... }

```
class Foo extends Object {
        Shoe m(Shoe x, Shoe y){ ... }
}

class Bar extends Foo {...}
```

# Method Declarations in Bar

- The result is method overriding
- The result is method overloading
- The result is a type-error
- None of the above




- FootWear m(Shoe x, Shoe y) { ... } **type-error**
- Shoe m(Shoe q, Shoe z) { ... } **overriding**
- HighHeeledShoe m(Shoe x, Shoe y) { ... } **overriding**
- Shoe m(FootWear x, HighHeeledShoe y) { ... } **overloading**
- Shoe m(FootWear x, FootWear y) { ... } **overloading**
- Shoe m(Shoe x, Shoe y) { ... } **overriding**
- Shoe m(HighHeeledShoe x, HighHeeledShoe y) { ... } **overloading**
- Shoe m(Shoe y) { ... } **overloading**
- Shoe z(Shoe x, Shoe y) { ... } **none (new method declaration)**

# Subclasses & Method Overriding

```
abstract class Bird {
 public abstract void speak();
 public void move() { System.out.println("flap flap!"); }
 public void move(int n) { move(); speak(); }
}
class Canary extends Bird {
 public void speak() { System.out.println("chirp!"); }
 public void move(int n) { speak(); speak(); }
}
class Duck extends Bird {
 public void speak() { System.out.println("quack!"); }
}
class RubberDuck extends Duck {
 public void speak() { System.out.println("squeak!"); }
 public void move() { speak(); swim(); }
 public void swim() { System.out.println("paddle!"); }
}
```

Given the declarations on the left, determine the outcome of the expressions below.

```
Bird b = new Bird();
b.move();
```

```
Bird b = new Canary();
b.move(17);
```

```
Bird b = new Duck();
b.move(42);
```

```
Bird b = new RubberDuck();
b.move(3);
```

```
Duck donald = new RubberDuck();
donald.swim();
```

```
Duck donald = new RubberDuck();
donald.move();
```

# Subclasses & Method Overriding

```
abstract class Bird {
 public abstract void speak();
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 public void move(int n) { speak(); speak(); }
}
class Duck extends Bird {
 public void speak() { System.out.println("quack!"); }
}
class RubberDuck extends Duck {
 public void speak() { System.out.println("squeak!"); }
 public void move() { speak(); swim(); }
 public void swim(                          paddle!"); }
}
```

Compile error: cannot create instances of an abstract class.

```
Bird b = new Bird();
b.move();
```

```
Bird b = new Canary();
b.move(17);
```

```
                    ();
b.move(42);
```

```
Bird b = new RubberDuck();
b.move(3);
```

```
Duck donald = new RubberDuck();
donald.swim();
```

```
Duck donald = new RubberDuck();
donald.move();
```

# Subclasses & Method Overriding

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class Duck extends Bird {
 public void speak() { System.out.println("quack!"); }
}
class RubberDuck extends Duck {
 public void speak() { System.out.println("squeak!"); }
 public void move() { speak(); swim(); }
 public void swim() { System.out.println("paddle!"); }
}
```

Chirp!
Chirp!

```
Bird b = new Bird();
b.move();
```

```
Bird b = new Canary();
b.move(17);
```

```
Bird b = new RubberDuck();
b.move(3);
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```
Duck donald = new RubberDuck();
donald.swim();
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```
Duck donald = new RubberDuck();
donald.move();
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# Subclasses & Method Overriding

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class Duck extends Bird {
 public void speak() { System.out.println("quack!"); }
}
class RubberDuck extends Duck {
 public void speak() { System.out.println("squeak!"); }
 public void move() { speak(); swim(); }
 public void swim() { System.out.println("p
}
```

flap flap!
quack!

```
Bird b = new Bird();
b.move();
```

```
Bird b = new Canary();
b.move(17);
```

```
Bird b = new
b.move(42);
```

```
Bird b = new RubberDuck();
b.move(3);
```

```
RubberDuck();
donald.swim();
```

```
Duck donald = new RubberDuck();
donald.move();
```

# Subclasses & Method Overriding

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 public void move() { speak(); swim(); }
 public void swim() { System.out.println("paddle!"); }
}
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Bird b = new Bird();
b.move();
```

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```
Bird b = new Duck()
b.move(42);
```

```
Bird b = new R
b.move(3);
```

```
RubberDuck();
```

```
RubberDuck();
donald.move();
```

```
squeak!
paddle!
squeak!
```

# Subclasses & Method Overriding

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abstract class Bird {
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}
class Duck extends Bird {
 public void speak() { System.out.println("quack!"); }
}
class RubberDuck extends Duck {
 public void speak() { System.out.println("squeak!"); }
 public void move() { speak();
 public void swim() { System.ou
}
```

Compile error: no swim method in class Duck

```
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b.move();
```

```
Bird b = new Canary();
b.move(17);
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Bird b = new Duck();
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Bird b = new RubberDuck();
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```
Duck donald = new RubberDuck();
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```

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class RubberDuck extends Duck {
 public void speak() { System.out.println("squeak!"); }
 public void move() { speak(); swim(); }
 public void swim() { System.out.println("paddle!"); }
}
```

```
Bird b = new Bird();
b.move();
```

```
Bird b = new Canary();
b.move(17);
```

```
Bird b = ne
b.move(42
```

```
Bird b = new RubberDuck();
b.move(3);
```

```
ld = new RubberDuck();
m();
```

```
donald = new RubberDuck();
donald.mov
```

squeak!
paddle!

# Event-Driven Programs

- Sits in an event loop, waiting for events to process
  - often does so until forcibly terminated
- Two common types of event-driven programs:
  1. GUIs
  1. Web servers
- Where is the event loop in Spark Java?
  - it is created behind the scenes

# Design Patterns

# Design Patterns

- Creational patterns: get around Java constructor inflexibility
  - Sharing: singleton, interning
  - Telescoping constructor fix: builder
  - Returning a subtype: factories

- Structural patterns: translate between interfaces
  - Adapter: same functionality, different interface
  - Decorator: different functionality, same interface
  - Proxy: same functionality, same interface, restrict access
  - All of these are types of wrappers

# Design Patterns

- Interpreter pattern:
  - Collects code for similar objects, spreads apart code for operations (classes for objects with operations as methods in each class)
  - Easy to add objects, hard to add methods
  - Instance of Composite pattern

- Procedural patterns:
  - Collects code for similar operations, spreads apart code for objects (classes for operations, method for each operand type)
  - Easy to add methods, hard to add objects
  - Ex: Visitor pattern

# Design Patterns

Adapter, Builder, Composite, Decorator, Factory, Iterator, Intern, Interpreter, Model-View-Controller (MVC), Observer, Procedural, Prototype, Proxy, Singleton, Visitor, Wrapper

- What pattern would you use to…
  - add a scroll bar to an existing window object in Swing
  - We have an existing object that controls a communications channel. We would like to provide the same interface to clients but transmit and receive encrypted data over the existing channel.
  - When the user clicks the “find path” button in the Campus Maps application (hw9), the path appears on the screen.

# Design Patterns

Adapter, Builder, Composite, Decorator, Factory, Iterator, Intern, Interpreter, Model-View-Controller (MVC), Observer, Procedural, Prototype, Proxy, Singleton, Visitor, Wrapper

- What pattern would you use to…
  - add a scroll bar to an existing window object in Swing
    - **Decorator**
  - We have an existing object that controls a communications channel. We would like to provide the same interface to clients but transmit and receive encrypted data over the existing channel.
    - **Proxy**
  - When the user clicks the "find path" button in the Campus Maps application (hw9), the path appears on the screen.
    - **MVC**
    - **Observer**