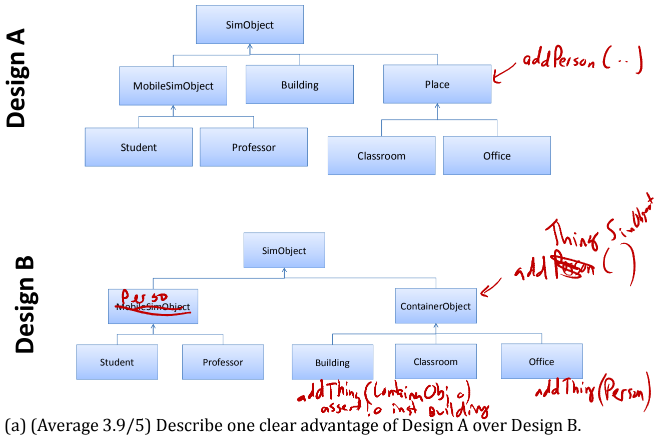
cs2220:
Engineering
Software

Class 27:
Exam 2

Fall 2010
UVa
David Evans

Menu

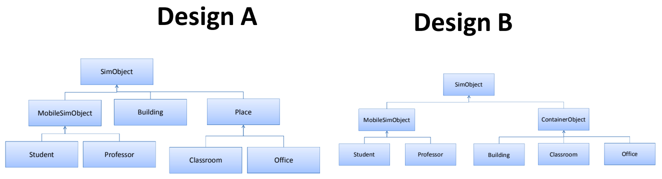
- Exam 2
- Parenthesizing the Expression



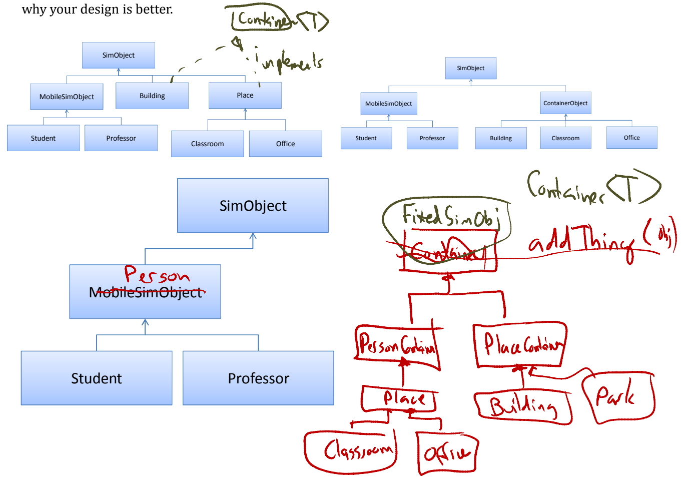
(a) (Average 3.9/5) Describe one clear advantage of Design A over Design B.
(b) (Average 4.5/5) Describe one clear advantage of Design B over Design A.

In general, what are possible **advantages** of one design over another?

- "Easier" to implement same function in one design
  straightforward, simple
- More natural mapping to problem
- → Less code to write - more reuse
- Thuthiness - more places where types can be checked statically
- Extensible



(c) (Average 7.7/10) Draw a better design than either Design A or Design B, and explain clearly why your design is better.



2(a). (4.2 / 5) Does the implementation of the Annihlator **destroy** method satisfy its specification? Your answer should either explain clearly why it does not, or use precise reasoning to argue why it does.

```
public class Annihilator {
  // OVERVIEW: An Annihilator is a mutable object that can kill and be killed by other
  //    objects.  A typical Annihilator is state where state is either Alive, Dying, or Dead.

  private int state;
  // A.F.(c): if c.state = 2, Alive; if c.state = 1, Dying; if c.state = 0, Dead.


  public void destroy(Annihilator a)

    // MODIFIES: a
    // EFFECTS: a_post = Dead
  { a.state = a.state - 1; }
```

⇒ a_{pre}.state = 1

concrete ⇒ a.state = 0

REQ: a is not Alive or Dead

2(b). (3.9 / 5) Does the Obliterator **destroy** method satisfy the substitution principle? A good answer will include a clear and convincing argument supporting your answer.

```
public class Annihilator {
  // OVERVIEW: An Annihilator is a mutable object that can kill and be killed by other
  //    objects.  A typical Annihilator is state where state is either Alive, Dying, or Dead.

  public void destroy(Annihilator a)
    // REQUIRES: a == Dying
    // MODIFIES: a
    // EFFECTS: a_post = Dead
  ...
}

  public class Obliterator extends Annihilator {
    @Override
    public void destroy(Annihilator a)
    // REQUIRES: a != Dead
    // MODIFIES: a
    // EFFECTS: a_post = Dead.
    ...
  }
```

1. Signatures
   same ✓
2. Method spec
   $\text{pre cond}_{SUPER} \Rightarrow \text{precond}_{SUB}$

Can we really answer this without an Overview spec for Obliterator?

2(c) (2.5 / 5) Suppose an Obliterator is always stronger than an Annihilator, so we override the Obliterator pickStronger method as:

```
  @Override
  public Obliterator pickStronger(Annihilator a)
    // EFFECTS: If a is not an Obliterator, returns this.  Otherwise, returns
    //    the stronger of this and a (or either one if they are equally strong),
    //    where Alive is stronger than Dying which is stronger than Dead.
  {
    if (a instanceof Obliterator) {
      if (isAlive() || (isDying() && !a.isAlive())) {  return this; }
      else { return (Obliterator) a; }
    } else {
      return this;
    }
  }
```

~~Easiest answer:~~

public Annihilator pickStronger(Annihilator)
// REQUIRES: true
// MODIFIES: anything (nothing works too)
// ENSURES: nothing

REQUIRES: true
MODIFIES: nothing
EFFECTS: does anything

✓ REQUIRES: false
MODIFIES: everything

Note that **we have not provided a specification for the Annihilator pickStrong method**. ***Could*** **the Obliterator pickStrong method satisfy the substitution principle?**

2(d) (challenge bonus) (+2; max +8) Note that our pickStronger comparisons are now not symmetric: a.pickStronger(b) is not necessarily equal to b.pickStronger(a). Explain a **general solution** to this problem. For maximum bonus, your answer should include correct code for your solution and an argument why it satisfies the symmetry property, clearly stating any assumptions on which that argument relies.

Note: general solution means it needs to work for ***all possible*** subtypes!

```
public class Annihilator {
      public Annihilator pickStronger(Annihilator a) {


      }
```

What do we know about the actual types of **this** and **a**?

2(d) (challenge bonus) (+2; max +8) Note that our pickStronger comparisons are now not symmetric: a.pickStronger(b) is not necessarily equal to b.pickStronger(a). Explain a **general solution** to this problem. For maximum bonus, your answer should include correct code for your solution and an argument why it satisfies the symmetry property, clearly stating any assumptions on which that argument relies.

Note: general solution means it needs to work for ***all possible*** subtypes!

```
public Annihilator pickStronger(Annihilator a) {
   if (?) { // something that always is symmetric!
      return a.pickStronger(this);
   } else {
     ... // normal body of pickStronger
   }
}
```

Best Idea (Jiamin Chen)

```
public class Annihilator {
  private int state;
→ private final int id;
  private static int counter = 0;

  public Annihilator () // EFFECTS: Initializes this to Alive.
  { state = 2; id = counter; counter++; }

  public Annihilator pickStronger(Annihilator a) {
    if (this.counter < a.counter) { // something that always is symmetric!
      return a.pickStronger(this);
    } else {
      ... // normal body of pickStronger
    }
  }
}
```

What if **this.counter == a.counter**?

Almost Works

```
public class Annihilator {
  public Annihilator pickStronger(Annihilator a) {
     if (hashCode() < a.hashCode()) {
       return a.pickStronger(this);
    } else {
       … // normal body of pickStronger
     }
  }
}
```

java.lang.Object public int **hashCode**()

final!

Returns a hash code value for the object. This method is supported for the benefit of hashtables such as those provided by java.util.Hashtable.

The general contract of hashCode is:

- Whenever it is invoked on the same object more than once during an execution of a Java application, the hashCode method must consistently return the same integer, provided no information used in equals comparisons on the object is modified. This integer need not remain consistent from one execution of an application to another execution of the same application.
- If two objects are equal according to the equals(Object) method, then calling the hashCode method on each of the two objects must produce the same integer result.
- It is not required that if two objects are unequal according to the equals(java.lang.Object) method, then calling the hashCode method on each of the two objects must produce distinct integer results. However, the programmer should be aware that producing distinct integer results for unequal objects may improve the performance of hashtables.

As much as is reasonably practical, the hashCode method defined by class Object does return distinct integers for distinct objects. (This is typically implemented by converting the internal address of the object into an integer, but this implementation technique is not required by the JavaTM programming language.)

3. Our philosophers from PS5 have decided that is it not natural or efficient to only argue with one other philosopher at a time. Instead, they should be able to argue with as many other philosophers as they want at once. The philosophers sit around a table (represented by the Table class), and take turns making their argument. It has the problem though, that philosophers will interrupt each other's argument. …

(a) (6.7 / 10) **Explain how to modify the code to prevent this race condition.** Your solution to not introduce any deadlocks in the code. For this part, ignore what happens when the philosopher wins enough points to leave the game.)

```
public boolean philosophize () {
   say("My turn!");
   for (Philosopher p : colleagues) {
     say(p.getName() + ", you are wrong! " + quote);
     points++;
     if (points > 20) {
        …
      }
   }
   say("Okay, I'm done.");
   return true;
 }
```

Locks, Threads, and Objects

Every **Object** has an associated **lock**

A **lock** is held by a **Thread**

(not by an Object or Class!)

Possible Answer #1

```
public boolean philosophize () {
   synchronize (this) {
     say("My turn!");
     for (Philosopher p : colleagues) {
       say(p.getName() + ", you are wrong! " + quote);
       points++;
       if (points > 20) {
         …
       }
     }
    say("Okay, I'm done.");
    return true;
   }
 }
```

Wrong Answer #2

```
public boolean philosophize () {
   say("My turn!");
   for (Philosopher p : colleagues) {
     synchronize (p) {
       say(p.getName() + ", you are wrong! " + quote);
       points++;
       if (points > 20) {
         …
       }
     }
   }
   say("Okay, I'm done.");
   return true;
  }
}
```

Wrong Answer #3

```
public class Philosopher {
  private ArrayList<Philosopher> colleagues;
  …
  public boolean philosophize () {
   synchronize (colleagues) {
     say("My turn!");
     for (Philosopher p : colleagues) {
          say(p.getName() + ", you are wrong! " + quote);
          points++;
          if (points > 20) {
             …
          }
        }
      say("Okay, I'm done.");
      return true;
   }
  }
}
```

Is it possible to lock all the colleagues?

Left as a challenge question… solution will give +30 points on Exam 2

(Almost) Correct Answer

```
public class Philosopher {
   private Table table;
   …
    // REQUIRES: p must be at the same table as this.
    //     …
    public synchronized void addColleague(Philosopher p) { … }

    public boolean philosophize () {
    synchronize (table) {
           say("My turn!");
           for (Philosopher p : colleagues) {
              say(p.getName() + ", you are wrong! " + quote);
              points++;
              if (points > 20) {
                …
              }
            }
           say("Okay, I'm done.");
           return true;
         }
   }
}
```

```
class Table {
  // OVERVIEW: A Table is a place
  //    where philosophers argue.
}
```

Correct Answer?

```
public class Philosopher {
   private Table table;
   …
    // REQUIRES: p must be at the same table as this.
    //     …
    public synchronized void addColleague(Philosopher p) { … }

    public boolean philosophize () {
      synchronize (this) {
        synchronize (table) {
          say("My turn!");
          for (Philosopher p : colleagues) {
              say(p.getName() + ", you are wrong! " + quote);
              points++;
              if (points > 20) {
                …
              }
            }
           say("Okay, I'm done.");
           return true;
         }
      } }
}
```

```
class Table {
  // OVERVIEW: A Table is a place
  //    where philosophers argue.
}
```

Fully Correct Answer

```
public class Philosopher {
   private Table table;
   …
    // REQUIRES: p must be at the same table as this.
    //     …
    public synchronized void addColleague(Philosopher p) { … }

    public boolean philosophize () {
      synchronize (table) {
        synchronize (this) {
          say("My turn!");
          for (Philosopher p : colleagues) {
              say(p.getName() + ", you are wrong! " + quote);
              points++;
              if (points > 20) {
                …      leaveTable()
              }
            }
           say("Okay, I'm done.");
           return true;
         }
      } }
}
```

```
class Table {
  // OVERVIEW: A Table is a place
  //    where philosophers argue.
}
```

3(b) (6.8 / 10) Are there any deadlocks or race conditions in **leaveTable**? If so, explain how to fix them. If not, explain why not.

```
public void goodbye(Philosopher p) {
      say("Goodbye "  + p.getName());
      colleagues.remove(p);
  }
private
 public void leaveTable() {
    for (Philosopher p : colleagues) {
      p.goodbye(this);
    }
    colleagues = null;
    table = null;
  }
```

4. As mentioned in Class 17, Barbara Liskov identified four main problems with Simula that motivated the design of CLU (from Barbara Liskov, A History of CLU, 1992). For each item below, explain how well the design of Java addresses the identified problem. Especially good answers will use concrete examples to show how the problem she identified either still exists in Java or has been avoided by Java.

(a) (4.3 / 5) "Simula did not support encapsulation, so its classes could be used as a data abstraction mechanism only if programmers obeyed rules not enforced by the language."

Encapsulation Packaging state with procedures.
(roughly, cs1120 definition)

Encapsulation The hiding of implementation details so that they are inaccessible outside of the module providing the implementation.
(Liskov's definition from textbook)

4(b). (3.4 / 5) Simula associated operations with objects, not with types.

Dyadic operators: 3 + 4
a equals b

Smalltalk: 3.add(4)
a.equals(b)

Java: 3 + 4 (operators for **primitive types** only)
a.equals(b)

CLU: math$add(a, b)
Object$equals(a, b)

Why is this a problem?

2(d) (challenge bonus) (+2; max +8) Note that our pickStronger comparisons are now not symmetric: a.pickStronger(b) is not necessarily equal to b.pickStronger(a). Explain a **general solution** to this problem. For maximum bonus, your answer should include correct code for your solution and an argument why it satisfies the symmetry property, clearly stating any assumptions on which that argument relies.

Note: general solution means it needs to work for ***all possible*** subtypes!

```
public Annihilator pickStronger(Annihilator a) {
   if (?) { // something that always is symmetric!
      return a.pickStronger(this);
   } else {
     ... // normal body of pickStronger
   }
}
```

Java (Sort-Of) Solution

Static methods:

method associated with Class, not Object

```
static public Annihilator pickStronger(Annihilator a, Annihlator b) {
  ...
}
```

Does this solve the problem with subtyping?

```
Annihilator.pickStronger(a, b);
a.pickStronger(a, b);
b.pickStronger(a, b);
```

4(c). (3.7 / 5) Simula "treated built-in and user-defined types non-uniformly. Objects of user-defined types had to reside in the heap, but objects of built-in type could be in either the stack or the heap."

Java still treats primitive types and Object types differently!

Exam Recap

- Exam questions meant to test:
  – Do you understand **specifications** and how to reason about procedures and data types
  – Do you understand **subtyping** and **inheritance**
  – Do you understand **concurrency** (locks, race conditions, deadlocks)
  – Do you understand tradeoffs between **expressiveness** and **truthiness**

Your oral final exam will give you one last chance to convince me the answer to all these questions is "Yes". Some of the questions will probably be based directly on things from this exam.

Parenthesizing Question

Given an arithmetic expression involving addition, subtraction, and multiplication of natural numbers, add parentheses to maximize the **value** of the expression.