CSE 331

Review: Classes, Inheritance, and Collections

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based on materials by M. Ernst, S. Reges, D. Notkin, R. Mercer, Wikipedia
http://www.cs.washington.edu/331/

Recall: A typical Java class

```
public class Point {
    private int x;                          // fields
    private int y;

    public Point(int x, int y) {            // constructor
        this.x = x;
        this.y = y;
    }

    public int getX() { return x; }         // accessor
    public int getY() { return y; }

    public void translate(int dx, int dy) {
        x += dx;
        y += dy;                            // mutator
    }

    public String toString() {              // for printing
        return "(" + x + ", " + y + ")";
    }
}
```

Effective Java Tip #10

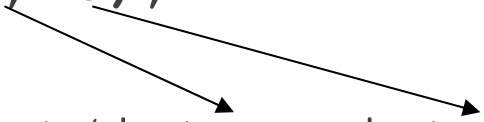
- Throughout this course, we will refer to design heuristics from Joshua Bloch's excellent *Effective Java* (2nd edition) book.

- **Tip #10:** Always override `toString`.

- Why?
  - If you can print your objects, you can easily see their state.
  - Clients can print your objects, which is a very common thing to do.
  - Clients can put them into collections and print the collection.
  - Nobody likes to see the default `"ClassName@a97e2f"` output.
  - Helps with debugging your own code as you're writing it.

Multiple constructors

```
public class Point {
    private int x;
    private int y;

    public Point() {
        this(0, 0);
    }

    public Point(int x, int y) {
        this.x = x;
        this.y = y;
    }
    ...
}
```



- Avoids redundancy between constructors
- Only a constructor (not a method) can call another constructor

Class question

- We are given a class `BankAccount` where each object represents a user's bank data such as name and balance.
- We must add functionality to the class so that each account object is automatically given a new unique ID number as it is created.
  - First account = ID 1; second account = ID 2; etc.

- How do we do it?

Static fields

```
private static type name;
```

or,

```
private static type name = value;
```

- Example:

```
private static int theAnswer = 42;
```

- **static**: Shared by all instances (objects) of a class.
  - A shared global field that all objects of the class can access/modify.
  - Like a class constant, except that its value can be changed.

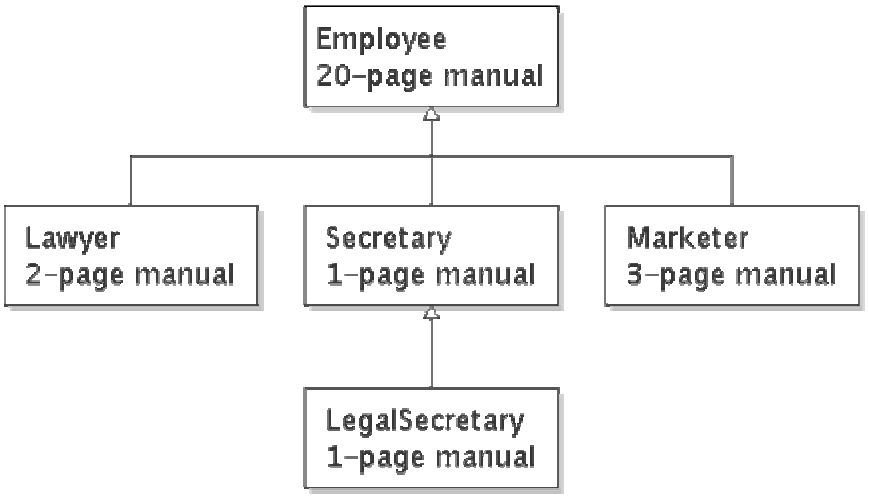
BankAccount solution

```
public class BankAccount {
    // static count of how many accounts are created
    // (only one count shared for the whole class)
    private static int objectCount = 0;

    private String name;    // fields (replicated
    private int id;         // for each object)

    public BankAccount() {
        objectCount++;      // advance the id, and
        id = objectCount;   // give number to account
    }

    ...

    public int getID() {    // return this account's id
        return id;
    }
}
```

- What would happen if `objectCount` were non-static? If `id` were static?

Recall: Inheritance

- **inheritance**: Forming new classes based on existing ones.
  - a way to share/**reuse code** between two or more classes
  - introduces **polymorphism** (can treat the classes the same way)
  - **superclass**: Parent class being extended.
  - **subclass**: Child class that inherits behavior from superclass.
  - **is-a relationship**: Each object of the subclass also "is a(n)" object of the superclass and can be treated as one.



A typical subclass

```
public class CheckingAccount extends BankAccount {
    private double fee;     // adding new state

    public CheckingAccount(String name, double fee) {
        super(name);        // call superclass c'tor
        this.fee = fee;
    }

    // adding new behavior
    public double getFee() {
        return fee;
    }

    // overriding existing behavior
    public void withdraw(double amount) {
        super.withdraw(amount + fee);
    }
}
```

- *Question:* Why not just add optional fee behavior to `BankAccount`?

Effective Java Tip #20

- **Tip #20:** Prefer class hierarchies to "tagged" classes.

- What's a "tagged" class, and why is it bad?
  - If we add the fee code to BankAccount, each object will need some kind of field to "tag" or flag whether it uses fees or not.
  - Adding that code complicates the existing class.
    - The new behavior will add ifs and logic to otherwise simple code.
  - BankAccount already works; why risk breaking it?
  - inheritance = **additive** rather than **invasive** change
    - The fee / no-fee logic will be decided entirely by the object type used.

Polymorphism

- **polymorphism**: Quality where the same code can be used with different kinds of objects and will behave in different ways.

- We can store a subclass object in a superclass variable.

```
BankAccount acct = new CheckingAccount("Bob", 1.50);
```

- We can pass a subclass object as a superclass parameter.

```
doStuff(acct);
...
public static void doStuff(BankAccount ba) {
```

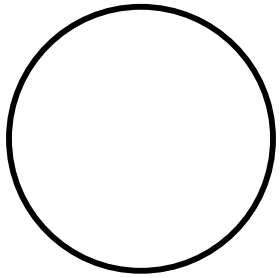
- The object we pass will always behave the same way ("its" way).
  - If `doStuff` calls `withdraw` on `acct`, the version from `CheckingAccount` is used.

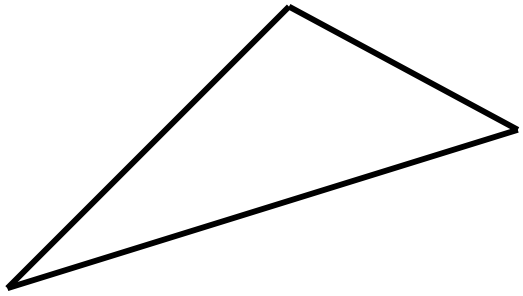
Recall: Interfaces

- **interface**: A list of methods that a class can promise to implement.
  - Gives an is-a relationship and polymorphism *without* code sharing.

- Consider shape classes `Circle`, `Rectangle`, and `Triangle`.

- Some things are common to all shapes but computed differently:
  - perimeter: distance around the outside of the shape
  - area: amount of 2D space occupied by the shape



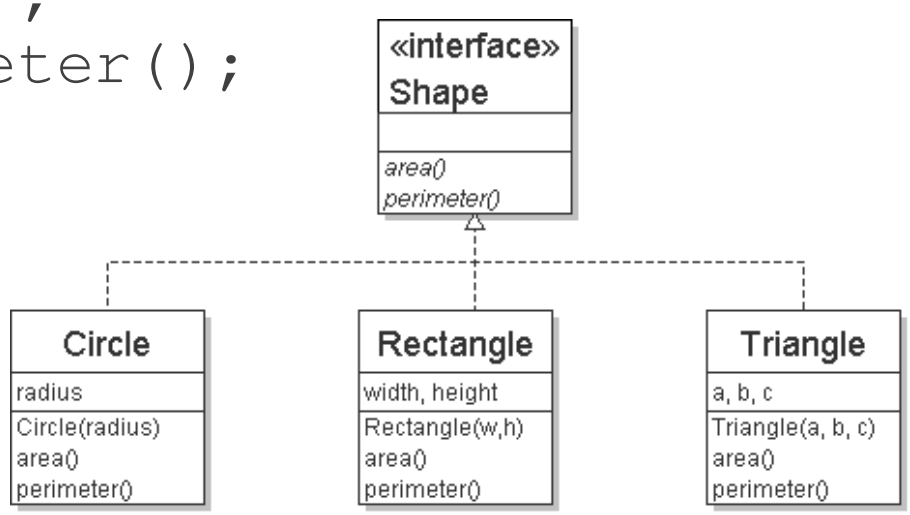


Interface syntax

```
public interface name {
    public type name(type name, …, type name);
    public type name(type name, …, type name);
    …
    public type name(type name, …, type name);
}
```

Example:

```
  public interface Shape {
      public double area();
      public double perimeter();
  }
```



Implementing an interface

```
public class name implements interface {
    …
```

- Example:

```
public class Rectangle implements Shape {
    ...
    public double area() { ... }
    public double perimeter() { ... }
}
```

- A class can declare that it "implements" an interface.
  - The class promises to implement each method in that interface.
    (Otherwise it will fail to compile.)

Collections as fields

- Many objects must store a collection of structured data.
  - Many data structures to choose from:
    - array, list, set, map, stack, queue, ...
  - Most kinds of collections have multiple implementations:
    - `List:` `ArrayList`, `LinkedList`
    - `Set:` `HashSet`, `TreeSet`, `LinkedHashSet`
    - `Map:` `HashMap`, `TreeMap`, `LinkedHashMap`
  - Which structure is best to use depends on the situation:
    - Does the data need to be in a particular order?
    - Are duplicates allowed?
    - Do we need to store pairs or look things up by partial values ("keys")?
    - How will we access the data (randomly, in order, etc.)?
    - ...

Collections summary

collection	ordering	benefits	weaknesses
array	by index	fast; simple	little functionality; cannot resize
`ArrayList`	by insertion, by index	random access; fast to modify at end	slow to modify in middle/front
`LinkedList`	by insertion, by index	fast to modify at both ends	poor random access
`TreeSet`	sorted order	sorted; O(log N)	elements must be comparable
`HashSet`	unpredictable	very fast; O(1)	unordered
`LinkedHashSet`	order of insertion	very fast; O(1)	uses extra memory
`TreeMap`	sorted order	sorted; O(log N)	elements must be comparable
`HashMap`	unpredictable	very fast; O(1)	unordered
`LinkedHashMap`	order of insertion	very fast; O(1)	uses extra memory

Effective Java Tip #25

- **Tip #25:** Prefer lists to arrays.

- In the majority of cases where you want to store structured data, a list works much better than an array. Why?
  - Lists automatically resize.
  - Lists contain more useful operations such as insertion, removal, toString, and searching (indexOf / contains).
  - Lists are more type-safe than arrays in certain cases.
    - Works: `BankAccount[] a = new CheckingAccount[10];  // bad`
    - Fails: `List<BankAccount> l = new ArrayList<CheckingAccount>();`

Abstract data types (ADTs)

- **abstract data type (ADT)**: A specification of a collection of data and the operations that can be performed on it.
  - The external view of a given type of objects.
  - Describes *what* an object does, not *how* it does it.
  - When you write classes, you are creating new ADTs.

- Clients of the object don't know exactly how its behavior is implemented, and they don't need to.
  - They just need to understand the idea of what the object represents and what operations it can perform.

Effective Java Tip #52

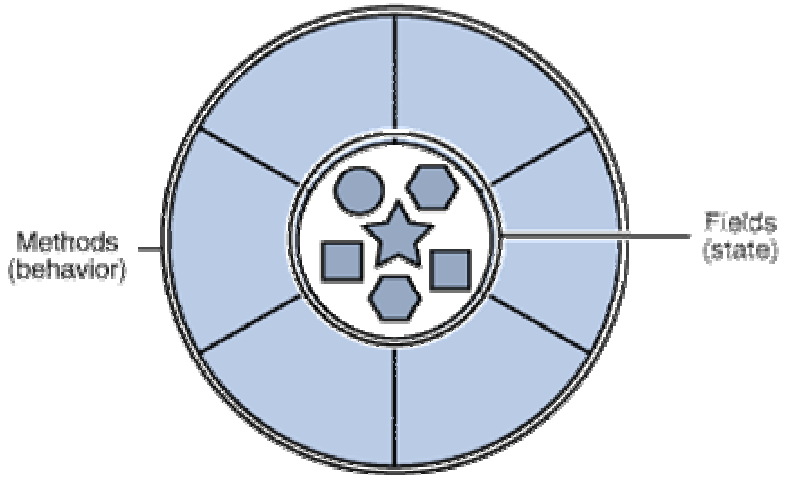
- **Tip #52:** Item 52: Refer to objects by their interfaces.
  - Bad: `ArrayList<String> list = new ArrayList<String>();`
  - Good: `List<String> list = new ArrayList<String>();`

- Why?
  - allows you to switch list implementations later if needed
  - keeps you from relying on behavior exclusive to ArrayList
  - also use the above style for declaring parameter / return types!

```
public static List<String> read(String file) {...
```

From spec to code

- As developers, we are often given a **spec** and asked to implement it.
- The spec may tell us what classes and public methods to write.
  (Later in this course, it won't...!)
  - Either way, it does **not** describe in detail how to implement them.



- We must figure out what internal **state** (fields) and helping behavior (methods) are necessary to implement the spec.

Spec-to-code question

- Let's implement a class `BuddyList` whose objects store all information about a user's instant messenger buddy list.

- Required functionality:
  - **create** a new empty buddy list for a given user name
  - **add** new buddies to the list (an object of type `Buddy`)
  - **examine** the buddies in the list, in unspecified order
  - **search** for a buddy in the list by name
  - **broadcast** a message to *all* of the buddies in the list
    - Note: All methods should be as efficient as possible.

- How should the class be implemented?
  - What are its methods and fields? What data structures to use?

Effective Java Tip #16

- **Tip #16:** Favor composition over inheritance.

- A BuddyList is similar to one of the existing Java collections, but with a bit of added functionality. So why not extend `HashMap`, etc.?
  - When you extend a class, your subclass inherits *all* of its behavior.
  - We don't want our buddy list to have all of those various methods.
    - BuddyList would now have methods like clear, retainAll, keySet, ...
    - This might expose the internal buddies data in ways we don't want.
  - This isn't a true "is-a" relationship. A buddy list isn't a map; it *uses* a map to help implement its functionality. It "has-a" map.
    - **composition**: Using another object as part of your state.