Class Design Guidelines

Ch 3.1-3.4

Topics

1) Do we have choices for class design?
2) Why bother encapsulating data?
3) Can we combine an accessor and mutator?

Class Design Alternatives

Day Class

- Task: Design a Day class
  - Represent the year, month, and day of month.
- Java provides the Date class

```
Date now = new Date();
System.out.println(now);          // calls.. date.toString()
```

```
Sun Feb 03 18:55:11 PST 2050
```

- Q: Whats confusing about the Date class?
  - Named Date, but also represents time
- How would we design our own class?

Day Class

- Class Responsibilities
  - Able to work with a calendar day
  - Work in.. days, months, years, or day numbers (Not time, no time-zones...)
- Public Interface

```
public class Day {
    public Day(int year, int month, int day);
    public int getYear();
    public int getMonth();
    public int getDate();
    public Day addDays(int n);
    public int daysFrom(Day other);
}
```

Calculate day in the future and “distance” between two days.

Example Client Code

```
public class DayTester {
    public static void main(String[] args) {
        Day start = new Day(2050, 1, 31);
        System.out.println("Start:     " + start);
        System.out.printf("Accessors:  year %d, month %d, day %d.%n",
                start.getYear(), start.getMonth(), start.getDate());

        Day tomorrow = start.addDays(1);
        System.out.println("Tomorrow:  " + tomorrow);

        Day future = start.addDays(1000);
        System.out.println("Future:    " + future);

        int daysInFuture = future.daysFrom(start);
        System.out.println("Future is  " + daysInFuture + " days away");
    }
}
```

```
Start:          2050-1-31
Accessors:      year 2050, month 1, day 31.
Tomorrow:       2050-2-1
Future:         2052-10-28
Future is       1000 days away
```

Deprecated

- Deprecated usually has improved alternatives
  - Parts of a public interface that are.. no longer supported or recommended
  - Usually means the deprecated part was not a good idea and has been redesigned.
- Java's Date class similar to Day
  - Date has many deprecated functions Ex: getMonth() should be avoided.
  - Use Calendar class instead.
  - Use built in Java classes when possible (here use Calendar instead of our Day).

Day: Design 1

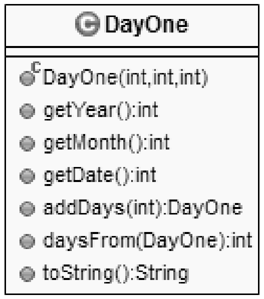
```
public class DayOne {
    private int year;
    private int month;
    private int date;
    public DayOne(int year,
            int month, int date) {
        this.year = year;
        this.month = month;
        this.date = date;
    }
    public int getYear() {
        return year;
    }

    private DayOne nextDay() {
        // .. omitted.
    }
// ... omitted
}
```

- Q: What's easy with this?
- Q: What's hard?
  - Days per month: 28, 30, 31
  - Leap years; no year 0.
- Efficiency
  - Coded via nextDay(), previousDay()
  - myDay.addDays(10000) runs 10,000 iterations!

Day: Design 2

Store day as a..

```
public class DayTwo {
        // Store the "Julian" day number.
        private int julian;

        //... omitted.
}
```



- Q: What's easy with this?
  -
    ```
    public int daysFrom(DayTwo other) {
            return julian – other.julian;
    }
    ```
- Q: What's hard?
  -

    (but not that complicated actually)
- Efficiency:
  ```
  System.out.printf("%d-%d-%d",
          d.getYear(), d.getMonth(), d.getDate());
  ```
  - Have to do three conversions with fromJulian()!

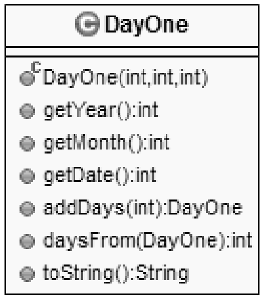
Day: Design 3

```
public class DayThree {
        private boolean ymdValid;
        private int year;
        private int month;
        private int date;

        private boolean julianValid;
        private int julian;

        // ... omitted
        public int getYear() {
                ensureYmd();
                return year;
        }
        public DayThree addDays(int n) {
                ensureJulian();
                // ... omitted
        }
}
```

- day number, and year/month/day.
- Lazy conversion: ..
  - If created via the day number, calculate year only when needed.
  - If created via year/month/day, calculate the day# when needed.
  - When a value is calculated..
- Functions check data validity:
  - If valid, then use it.
  - If invalid, calculate it & save answer.

Day: Design 3 (cont)

```
public class DayThree {
        private boolean ymdValid;
        private int year;
        private int month;
        private int date;

        private boolean julianValid;
        private int julian;
        // ... omitted
}
```



- Q: What's easy?
  - All code is..
- Q: What's hard?
  -
- Q: What's the benefit of using lazy conversion and storing result?
  -

    Only do the work when needed; only do the work once.
- Q: What is the cost?
  - Slightly more..

Day Design Summary

- Implementations:
  - DayOne: Work on year, month, day.
  - DayTwo: Work on a day's number (Julian day).
  - DayThree: Lazy conversion between both.
- Which is best?
  - Working with:
    - Year/Month/Day: DayOne
    - Julian days (addDays(),...): DayTwo
    - Efficiency: DayThree
      Simplest code: not DayThree

Encapsulation
Ch 3.4

Encapsulation

- What's wrong with Day (on right)
  -

```
public class Day {
    public int year;
    public int month;
    public int day;
    // ... omitted.
}
```

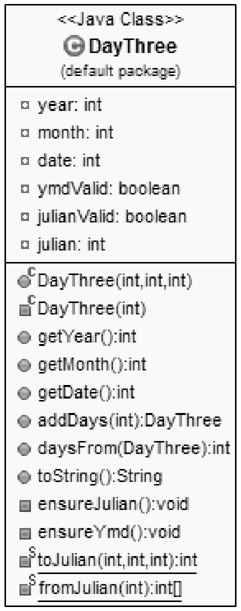
- Q: Why is this bad?
  - If we switched to lazy calculations, must access data through public methods (DayThree):
    Must convert use of public variables to methods:

```
int year = myDay.year;
becomes
int year =
```

```
myDay.year++;
becomes
myDay = new Day(
        myDay.getYear() + 1,
        myDay.getMonth(),
        myDay.getDay());
```

Day Interface Design

- Day Class's Interface
  - The “helper” functions are private
  - Ex: ensureJulian(), toJulian()
- Why keep helper methods private?
  -
    able to change private details without having to re-write clients.
  - Expose only enough functionality to do the job!



Breaking Encapsulation

- Breaking encapsulation bad because..
  - What's hidden can change easily:..
  - Seems overkill for small projects, but pays off on large projects.

Always code like your code matters.

- Benefits of Encapsulation
  -
  - Reduces the amount a developer has to keep in mind at once:..

Immutable

- Immutable: an object with..
  - Once created, you cannot change it's (visible) state.
- Q: Is DayThree immutable?
  - Lazy conversion changes its private fields.
  -

    externally it has the same state.
- Immutability implications for Day
  - addDays() must returns..
  - Similar to String.toLower():
    String msg = “Hello World”.toLower();

Why go Immutable?

- Avoids setter problems
  What day should this create?
  ```
  Day start = new Day(2000, 1, 31);
  start.setMonth(2);
  ```
    - Feb 28?
    - Mar 3?
  - setMonth() would have to make an arbitrary choice on how to adjust the day to become valid.
- Shared reference
  - Cannot change behind your back.
- Thread-safe (later)

Shared Reference Problem

- Client w/ Mutable Date:
  - Date is *mutable* (supporting setTime()).
  - What's the problem with the following?

```
public class Person {
    private Date birthDay;
    public Person(Date bDay) {
        birthDay = bDay;
    }
    public Date getBirthDay() {
        return birthDay;
    }
}
```

```
private static void exploitGetBirthDay() {
    Person george = new Person(new Date());
    System.out.println(
        "Before: " + george.getBirthDay());

    Date date = george.getBirthDay();
    date.setTime(0);

    System.out.println(
        "After:  " + george.getBirthDay());
}
```

Clone() solution

- Protect Person from unexpected change:
  - Use an   date object; or
  - Use clone() to return a..
    vs a reference to the original object.

```
public class PersonWithClone {
    private Date birthDay;
    public PersonWithClone(Date birthDay) {
        this.birthDay = (Date) birthDay.clone();
    }

    public Date getBirthDay() {
        return (Date) birthDay.clone();
    }
}
```

Accessor Safety

- Is it "safe" (i.e., unchangable) for an object's accessor to return . . .
  - a reference to a field of a mutable type? (Ex: Date)

    No: shared reference
  - a reference to a field of a immutable type? (Ex: String)

    Yes: cannot change object
  - a primitive typed field? (Ex: int)

    Yes: pass by value
- Immutable objects prevent (unexpected) change.
  - Only make an object *mutable* if you expect it to change over time
  - Ex: A message queue, a person, etc.

Final Fields

- A field can be marked final meaning..

  a var cannot be made to reference another object

  (or change its value if a primitive)
- Can be assigned a value either:

  a)..when declared

```
private class Car {
    final private String MAKE = "PORCHE";
}
```

  b).. once during constructor

```
private class Truck {
    final private String MAKE;
    public Truck() {
        MAKE = "Ford";
    }
}
```

final Example

```
public class Grade {
    public final int MAX_PERCENT = 100;
    private final ArrayList<Person> list;
    public Grade() {
        list = new ArrayList<Person>();
    }
```

Which generate compiler errors?

a)

b) ye boi, lvalue is final

c) ye boi, lvalue is final

d)

e)

```
// ... cont...
public void doSomething() {
    // Which of the following lines fail?
    // a) Constant to variable & change?
    int w = MAX_PERCENT;
    w++;

    // b) Change constant?
    MAX_PERCENT = 50;

    // c) Change which object?
    list = new ArrayList<Person>();

    // d) Access from object?
    int x = list.size();
    x++;

    // e) Change object's state?
    list.add(new Person(new Date()));
}
}
```

var is final; object is still mutable

Command/Query Separation (Guideline)

A good idea; not a rule.

Command-Query Separation

- Command: A method which.. changes an object (sometimes called a mutator)
- Query: A method which.. returns object state without mutating it (sometimes called an accessor)
- Command-Query Separation Guideline: Each method should do at most one of:
  - Change state of an object.
  - Return a value/part of the state.
- Q: What is an object with no command methods?
  - immutable (no mutators)

Violation

- Example violation of Command-Query Separation

```
public class BankAccount {
    private int balance = 0;

    public int getBalance(int value) {
        return balance -= value;
    }
}
```

- Two required changes to fix:

1. rename to withdraw
2. Don't..return the new value
   write an actual getBalance().

Iterators

- Iterators:.. abstract iteration over a data set

```
public class IteratorExample {
    public static void main(String[] arg) {
        // Create the list
        List<String> data = new LinkedList<>();
        for (int i=0; i < 5; i++) {
            data.add("Value " + i);
        }

        // Standard for loop
        for (int i = 0; i < data.size(); i++) {
            System.out.printf("%d = %s%n", i, data.get(i));
        }

        // Iterator
        Iterator<String> itr = data.iterator();
        while (itr.hasNext()) {
            System.out.printf("%s%n", itr.next());
        } // prevents off by 1 errors
    }
}
```

```
interface Iterator<E> {
    boolean hasNext();
    E next();
    void remove();
}
```

.iterator() returns an.. iterator object

Iterator is a generic.

- next() returns the next element and advances

Exercise

- Complete this function, **using an iterator**, to add up all numbers in the following collection:

```
int sumListOfIntegers(List<Integer> data) {
    Iterator<Integer> itr = data.iterator();
    int total = 0;

    while(itr.hasNext()) {
        total += itr.next();
    }
    return total;

}
```

Iterators

- What violates command-query separation?
  - iterator.next(): moves to next elem AND reads state

```
public class IteratorExample {
     public static void main(String[] arg) {
          List<String> data = new LinkedList<>();

          // ... adding items omitted.

          Iterator<String> itr = data.iterator();
          while (itr.hasNext()) {
               System.out.printf("%s%n", itr.next());
          }
     }
}
```

- Individual methods for access (query/accessor) and change (command/mutator) often better.
  - Try to make commands (mutators) return void.

Side Effects

- Side Effect:
  an observable change in state after code executes
  - Ex: x = 10; y++; myDate.setTime(0);
  - Mutators have side effects:
    they change data on their object.
- Other possible side effects
  - change parameters unexpectedly

```
void setDate(Date date) {
  date.setTime(0);
  this.date = date;
}
```

- Expectation
  - Don't change the parameters you are passed unless purpose of a method.

Bad Code Example

- What's wrong with this code trying to add up all positive numbers in the list?

```
public class BadIteratorExample {
     public static void main(String[] arg) {
          List<Integer> data = new LinkedList<Integer>();

          // ... adding items omitted.

          int sum = 0;
          Iterator<Integer> itr = data.iterator();
          while (itr.hasNext()) {
               if (itr.next() >= 0) {                ..
                    sum += itr.next();  // next() mutates itr
               }                        each time it is ran
          }
     }                                  // will also go out of range
}                                       in odd # of elements
```

Iterable

Adding for-each support

- How can custom classes support the for-each loop?
  - Ex: In a University's system, a Major class stores a set of required Courses (among other things):

```
// Inside Student class:
bool passedDegreeRequirements(Major major) {
    for (Course course : major) {
        if (!hasPassed(course)) {
            return false;
        }
    }
    return true;
}
```

Iterable<T>

- for-each loop.. works on iterable objects (those that implement Iterable)

```
interface Iterable<T> {
    Iterator<T> iterator();
}
```

- Make your collection classes implement Iterable!

```
public class Major implements Iterable<Course> {
    private List<Course> courses =
            new ArrayList<Course>();
    // Code omitted...

    @Override
    public Iterator<Course> iterator() {
        return courses.iterator();
    }
}
```

// need override method if calling `implement`

Two Problems

```
public class IterableDemo {
  public static void main(String args[]) {
     Major sosyMajor = new Major("SOSY Major");
     sosyMajor.addCourse(new Course("CMPT 130"));
     ...
     for (Course course : sosyMajor) {
        System.out.println("  " + course);
     }
  }
}
```

```
public class Major implements Iterable<Course>{
   private List<Course> courses =
           new ArrayList<Course>();
   // Code omitted...

   @Override
   public Iterator<Course> iterator() {
       return courses.iterator();
   }
}
```

- Does it make sense that iterating over a major gives courses?
- Why not iterate over:
  - Students?
  - Semesters?
- Iterator has a remove() method!
- What if I don't want allow others to remove objects?

Selecting the Iterator

- Make a function that.. returns an anonymous iterable object
- Client code can request the correct set of objects to iterate over by name.

```
public class Major {
    public Iterable<Course> courses() {
        return new Iterable<Course>(){
            @Override
            public Iterator<Course> iterator() {
                return courses.iterator();
            }
        };
    }
    public Iterable<Student> students() {...}
    public Iterable<Semester> semesters() {...}
}}
```

```
Usage in client code:
  for (Student student : sosyMajor.students()) {
     ...
  }
```

Unmodifiable

- Prevent client code from modifying the list via the iterator's remove() method by..
  using an modifiable view of your collection

```
public class Major {
  private List<Course> courses = new ArrayList<Course>();

  public Iterable<Course> courses() {
    return new Iterable<Course>(){
      @Override
      public Iterator<Course> iterator() {
        return Collections.unmodifiableCollection(courses).iterator();
      }
    };
  }
}
```

Custom Iterator

Write your own iterators when needed.

Implement iterator() function returning an iterator supporting hasNext() and next().

```
public class Matrix implements Iterable<Integer>{
    public static int NUM_ROWS;
    public static int NUM_COLS;
    private int[][] values;

    @Override
    public Iterator<Integer> iterator() {
        return new Iterator<Integer>() {
            int row = 0, col = 0;
            @Override
            public boolean hasNext() {
                return (row < NUM_ROWS) && (col < NUM_COLS);
            }
            @Override
            public Integer next() {
                Integer item = values[row][col];
                // ... code to advance col and row...
                return item;
            }
            @Override
            public void remove() {
                throw new UnsupportedOperationException();
            }
        };
    }
}
```

Iterator Advice

- Use for-each loops when iterating over data.
- If your class has an obvious set of items to iterate over .. implement iterable
- If your class has non-obvious sets of items to iterate over, have.. methods that return iterable objects
- Get most iterators by just returning the iterator on your data structure:
  return myArrayList.iterator();
- Almost always make unmodifiable views before returning an iterator:
  return Collections.unmodifiableCollection(myArray).iterator();

Summary

- Three Day class design options
  - DayOne: Work on year, month, day.
  - DayTwo: Work on a day's number (Julian day).
  - DayThree: Lazy conversion between both.
- Encapsulation: Limit scope of changes.
- Immutable: Visible state unchangeable
  - No shared reference problems.
- Final fields: Variable cannot be changed.
- Command Query Separation
- Iterators and Iterable