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..
```

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

- Q: Whats confusing about the Date class?
  -
- How would we design our own class?

Day Class

- Class Responsibilities
  - Able to work with a calendar day
  - Work in..
    (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
  - Parts of a public interface that are..
  - 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

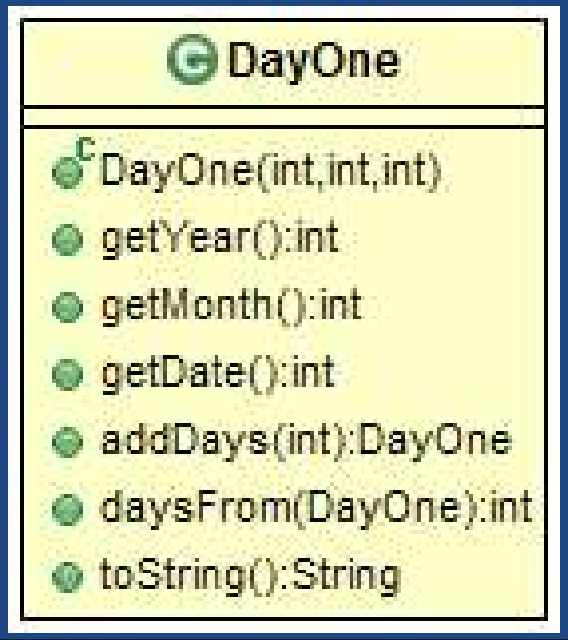
```
public class DayOne {
    private int year;
    private int month;
    private int date;

    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()!

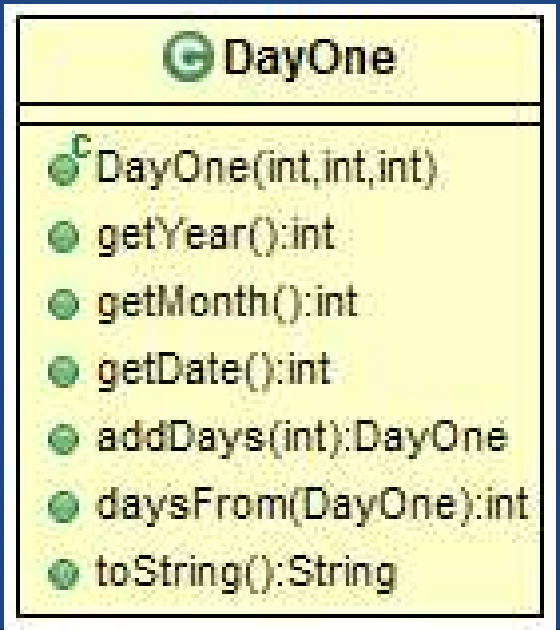
Day: Design 3

```
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)
  -
- 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:

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

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

becomes

```
int year =
```

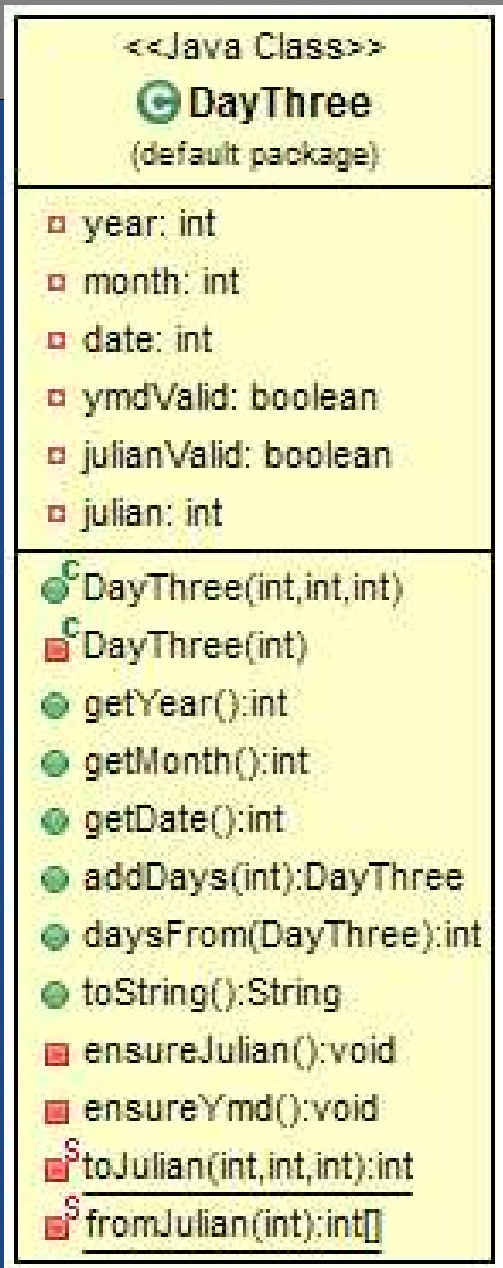
```
myDay.year++;
```

becomes

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

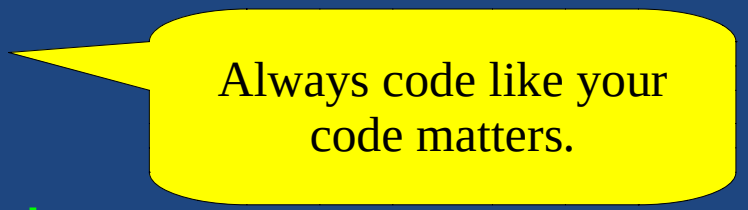
Day Interface Design

- 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.



- 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)
  - a reference to a field of a immutable type? (Ex: String)
  - a primitive typed field? (Ex: int)
- 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..

- Can be assigned a value either:

a)..

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

b)..

```
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>();
    }

    // ... 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()));
    }
}
```

Which generate compiler errors?

a)

b)

c)

d)

e)

Command/Query Separation (Guideline)

A good idea;
not a rule.

Command-Query Separation

- Command: A method which..
  (sometimes called a mutator)
- Query: A method which..

  (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?
  -

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.
2. Don't..
   write an actual getBalance().

Iterators

- Iterators:..

```
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());
        }
    }
}
```

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

.iterator() returns an..

Iterator is a generic.

Exercise

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

```
int sumListOfIntegers(List<Integer> data) {




}
```

Iterators

- What violates command-query separation?
  - –

```
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:
  - Ex: x = 10; y++; myDate.setTime(0);
  - Mutators have side effects:
    they change data on their object.
- Other possible side effects
  -

```
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();
            }
        }
    }
}
```

Iterable

Adding for-each support

- How can custom classes support the for-each loop?
  - Ex: In a recording Artist class stores a set of Song objects (among other things):

Inside Main class:

```
public boolean hasPlatinumSong(Artist artist) {
    for (Song song : artist) {
        if (song.isPlatinum()) {
            return true;
        }
    }
    return false;
}
```

Iterable<T>

- for-each loop..
  (those that implement Iterable)

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

- Make your collection classes implement Iterable!

```
public class Artist implements Iterable<Song>{
    private List<Song> songs = new ArrayList<>();

    // Other functions omitted

    @Override
    public Iterator<Song> iterator() {
        return songs.iterator();
    }
}
```

Two Problems

- Does it make sense that iterating over an Artist gives Songs?
  - Why not iterate over an Artist for:
    - Albums?
    - Concerts?

- Iterator has a remove() method!
  - What if I don't want allow others to remove objects?

Selecting the Iterator

- Make a function that..

```
public class Artist {
    // Return Iterable objects:
    public Iterable<Song> songs() {
        return new Iterable<Song>() {
            @Override
            public Iterator<Song> iterator() {
                return songs.iterator();
            }
        };
    }

    public Iterable<Album> albums() {...}
    public Iterable<Concert> concerts() {...}
}
```

- Client code can request the correct set of objects to iterate over by name.

```
Usage in client code:
  Artist bach = new Artist();
  for (Album album : bach.albums()) {
     // use album here...
  }
```

Unmodifiable

- Prevent client code from modifying the list via the iterator's remove() method by..

```
public class Artist implements Iterable<Song>{
    private List<Song> songs = new ArrayList<>();

    @Override
    public Iterator<Song> iterator() {
        return Collections.unmodifiableCollection(songs).iterator();
    }
}
```

It actually creates a wrapper object that hides the underlying collection.

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 ..
- If your class has non-obvious sets of items to iterate over, have..
- 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