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()
```

print out: `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
  - 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 LocalDate or LocalDateTime class instead.
  - Use built in Java classes when possible
    (here use LocalDate instead of our Day).

Day: Design 1

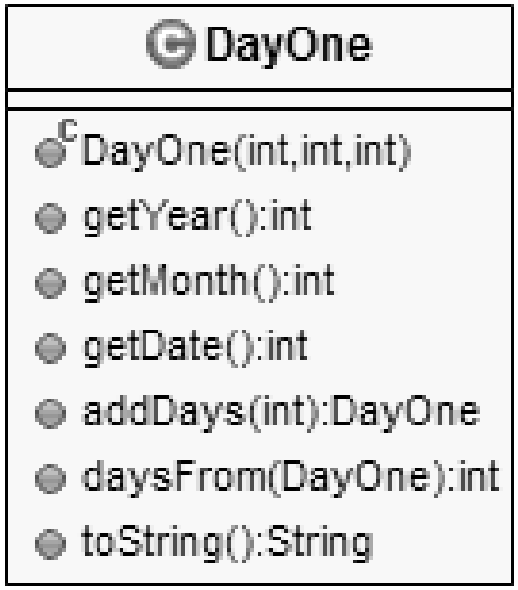
```
public class DayOne {
	private int year;
	private int month;
	private int date;

	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
}
```

- store year, month, day as fileds
- Q: What's easy with this?
  constructors, accessors
- Q: What's hard?
  addDays(), daysFrom()
  - 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. day number since a fixed start day

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

    //... omitted.
}
```



- Q: What's easy with this?
  - addDays(), daysFrom()

```
public int daysFrom(DayTwo other) {
    return julian – other.julian;
}
```

- Q: What's hard?
  - constructor, accessors: getYear()

  (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()!

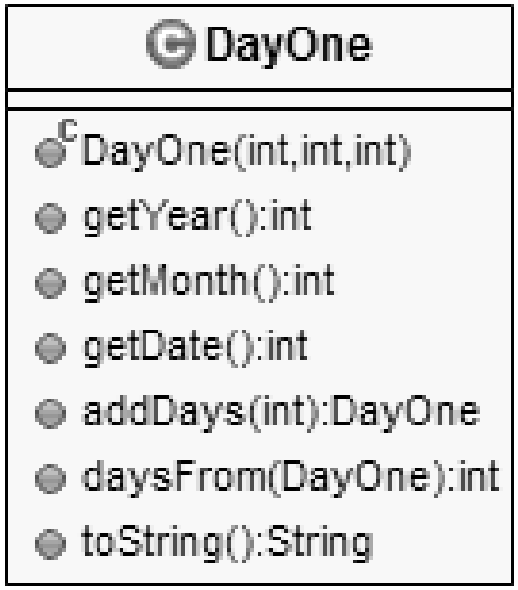
Day: Design 3

```
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
    }

}
```

- store both day number, and year/month/day.
- Lazy conversion: calculate when needed
  - 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.. cache it for future use
- 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..
    reasonably straight forward
- Q: What's hard?
  - extra work maintaining the valid-flags
- Q: What's the benefit of using lazy conversion and storing result?
  - efficiency: aka cache

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

    More space

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?

  depends on the application
  - 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)
  - directly exposes data

```
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.getYear();
```

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

becomes

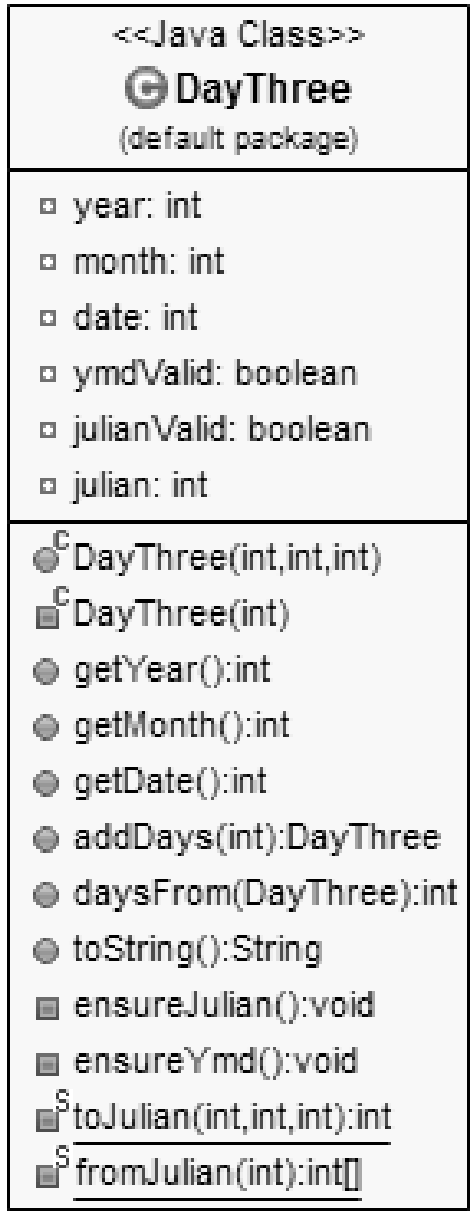
```
myDay = new Day(
        myDay.getYear() + 1,
        myDay.getMonth(),
        myDay.getDay());
```

Day Interface Design

note: we want as much as private as possible

- Day Class's Interface
  - The “helper” functions are private
  - Ex: ensureJulian(), toJulian()
- Why keep helper methods private?
  - Encapsulation:

    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..
  extensive changes inhibit making updates
  - What's hidden can change easily:..
    promotes refactoring
  - Seems overkill for small projects, but pays off on large projects.

Always code like your code matters.

- Benefits of Encapsulation
  - reduces the scope of a change
  - Reduces the amount a developer has to keep in mind at once:.. reduced cognitive load

Single Responsibility Class: a class should have 1 reason to change

Immutable

- Immutable: an object with.. no methods that change its visible state
  - Once created, you cannot change it's (visible) state.
- Q: Is DayThree immutable?
  - Lazy conversion changes its private fields.
  - it's immutable:

    externally it has the same state.
- Immutability implications for Day
  - addDays() must returns.. a new Day object
  - 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);
    client changes george's birthday
    System.out.println(
        "After:  " + george.getBirthDay());
}
```

problem here: shared reference (birthday):
-getBirthDay return a reference to birthday field
-later on the client calls setTime on that reference

Clone() solution

java copy constructor

- Protect Person from unexpected change:
  - Use an immutable date object; or
  - Use clone() to return a duplicate object 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();
    }
}
```

clone() has return type of Object
--> need to cast to Date

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 the object (String is an immutable — can not be changed)
  - 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 *final and immutable are not the same, but similar

- A field can be marked final meaning..

  variable cannot be made to reference another object
  (or change it value if a primitive)

- Can be assigned a value either:

  a)..when declared

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

  b)..once during the 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) No bcuz int will pass by value

b) Yes

c) Yes, bcuz we're trying to change reference to new object

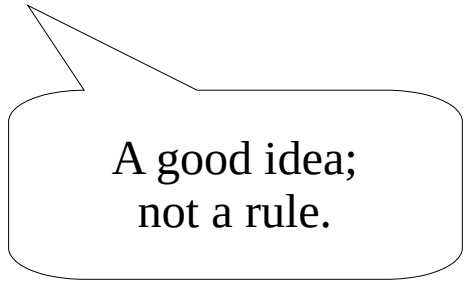
d) No

e) No bcuz object is still mutable

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


Note: mutability is not something deal with keyword,
it's about how u design
bcuz only found mutable or not at compile time

Command/Query Separation (Guideline)



Command-Query Separation

- Command: A method which.. changes an object
  (sometimes called a mutator)
- Query: A method which..
  returns the state of an object without changing 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

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 value
     write an actual getBalance().

when doing code review, think about:
shared reference
—> should follow principle of least surprise

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());
        }
    }
}
```

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

.iterator() returns an.. Iterator object ..

Iterator is a generic. ..

next() returns next element and advances ..

-> violate command query

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 sum = 0;
while (itr.hasNext()) {
 sum += itr.next();
}
return sum;




}
```

Iterators

- What violates command-query separation?
  - itr.next(): moves to next, 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 to 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 parameter 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();
            }
        }
    }
}
```

common bug:
calling next() more than once

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. works on Iterable objects
  (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();
    }
}
```

reason why we have an iterator here:
-external code needs to access list of songs
+if we make the list to be public -> violate encapsulation
+"make the class iterable" (overrides iterator method) could return the list
-> allow external code to interact with the song list
-> not the best option but still a good start

Two Problems with Iterator

- 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

solution:

can make these shorter by using lambda expressions

- Make a function that..

return an anonymous Iterable object

```
public class Artist {
    // Return Iterable objects:
    public Iterable<Song> songs() {
        return new Iterable<Song>() {
            @Override return an anno class and anno object
            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...
  }
```

albums() could be thought of static factor method

Unmodifiable

solution for problem 2:

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

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

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

this is a static method that:
-creates a wrapper object sit on top of the real song list
-it will override the remove method in iterator
(just throwing exception)

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 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