CMSC 131
Object-Oriented Programming I

Privacy Leaks, Copying Objects

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This material is based on material provided by Ben Bederson, Bonnie Dorr, Fawzi Emad, David Mount, Jan Plane
Overview

- Privacy Leaks
- Copying objects
- Two-Dimensional Arrays
Privacy Leaks

```java
class MutableThing {
    ...
    public void mutateMe() {...};
}
class Foo {
    private MutableThing q = new MutableThing();
    ...
    public MutableThing getQ(){
        return q;
    }
}
```

Consider following code
```java
Foo f = new Foo();
MutableThing m = f.getQ();
m.mutateMe();
```

After this executes, what happens?

- This phenomenon is called a privacy leak
  - Private instance variables can be modified outside class
  - Behavior is due to aliasing
  - **Example:** privacyLeak package
Fixing Privacy Leaks

- Return copies of objects referenced by instance variables
  - To fix getQ method in Foo:
    ```java
    MutableThing getQ(){
        return new MutableThing(q);
    }
    ```
    - This returns a copy of q
    - Changes made to this copy will not affect original
We can define three ways to copy objects
- Shallow Copying
- Reference Copying
- Deep Copying

Let’s see examples in the context of arrays
Shallow Copying

Person[] d = {
    new Person(2.1, 7, ...),
    new Person(3.3, 2, ...)
};

Person[] e = new Person[d.length];
for (int i = 0; i < d.length, i++){
    e[i] = d[i];
}
Reference Copying

Person[] d = {
    new Person(2.1, 7, ...),
    new Person(3.3, 2, ...)
};

Person[] e = d;
Person[] d = {
    new Person(2.1,7,...),
    new Person(3.3,2,...)
};

Person[] e = new Person[d.length];
for (int i=0; i<d.length; i++) {
    e[i] = new Person(d[i]);
}
Example

- CDCollector contains an array of CD's;
- ReCDCollector contains an array of rewritableCD's

**Reference Copy**

```java
public ReCD[] getCDsReferenceCopy() {
    return myFavorites;
}
```

**Shallow Copy**

```java
public ReCD[] getCDsShallowCopy() {
    ReCD[] copy = new ReCD[myFavorites.length];
    for (int i = 0; i < copy.length; i++)
        copy[i] = myFavorites[i];
    return copy;
}
```

**Deep Copy**

```java
public ReCD[] getCDsDeepCopy() {
    ReCD[] copy = new ReCD[myFavorites.length];
    for (int i = 0; i < copy.length; i++)
        copy[i] = new ReCD(myFavorites[i]);
    return copy;
}
```

```java
ReCDCollectionOwner p = new RECD…;
ReCD[] a = p.getCD…();
a[0] = otherCDalreadycreated;
a[0].rewrite(“other”, ”name”);
```
When to Use What kind of Copying?

- Deep copying provides maximal protection against aliasing (but takes a lot of time and space if it is not necessary)
- Storage space and time used
  - Reference -> least
  - Shallow -> middle
  - Deep -> most
- If the class is mutable, aliasing is something to be avoided and you must have true copies to prevent privacy leaks and modifications outside
- If you know the class is immutable, aliasing doesn’t hurt but neither does making true copies (except wasted space and time)
- If storage is an issue, aliasing problems may be worth copying with but must be well documented
Remember that prime numbers
- Prime number → positive integer that has exactly two positive integer factors, 1 and itself
- Prime number → integer that is not the product of two smaller integers
- 1 is not a prime number

Computing prime numbers using Sieve of Eratosthenes

Example: Driver.java, PrimeGenerator.java

Information about Sieve of Eratosthenes
Arrays Class (Honors)

- Arrays class (notice the s) contains various methods for manipulating arrays
  - Sorting
  - Searching (binary search)
  - Copying of arrays (equality)
  - Comparison of arrays (are they deep copies?)
  - Array initialization
  - String representation of arrays

- Let’s see the Java API
  - [http://download.oracle.com/javase/6/docs/api/index.html](http://download.oracle.com/javase/6/docs/api/index.html)