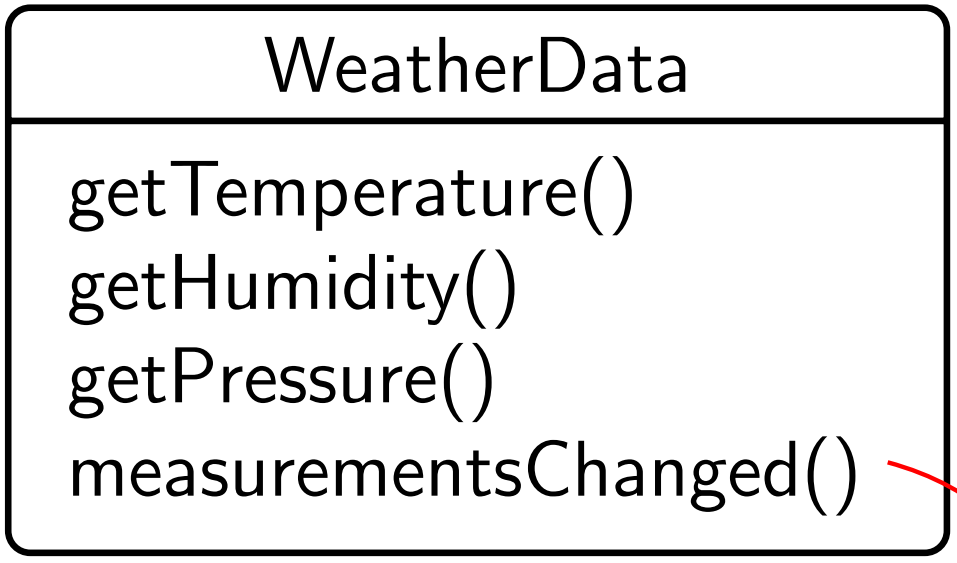
CS 351
Design of Large Programs
Observer Pattern

September 27, 2021

A Weather Monitoring Application

- We have a weather station with humidity, temperature, and pressure sensors
- We are implementing a WeatherData object that pulls data from the weather station.
- Create an app that uses the WeatherData object to update three different displays:
  - current conditions
  - weather stats
  - forecast

What Needs to be Done?



Update three different displays

```
/**
 * Call this method whenever
 * measurements are updated
 */
public void measurementsChanged(){
    // your code goes here
}
```

Problem Specification

- The `WeatherData` class has getters and setters for temperature, humidity, and pressure
- The `measurementsChanged()` method is called anytime new weather data is available
  - We don't know or care how!
- We need to implement three different display elements that use the weather data
- The system must be expandable, in case others want to add other display elements later

A First Attempt to Coding

```
public class WeatherData {

  //instance variable declarations

  public void measurementsChanged(){
    float temp = getTemperature();
    float humidity = getHumidity();
    float pressure = getPressure();

    currentConditionsDisplay.update(temp, humidity, pressure);
    statisticsDisplay.update(temp, humidity, pressure);
    forecastDisplay.update(temp, humidity, pressure);

  }

  // other methods
}
```

- **What's wrong?**

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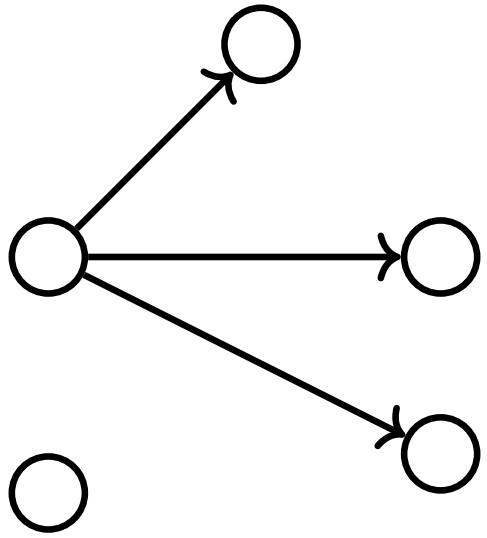
- **What's wrong?**
- Coding to implementations: adding displays requires changing the program
- Encapsulate stuff that changes!

S

Publish/Subscribe

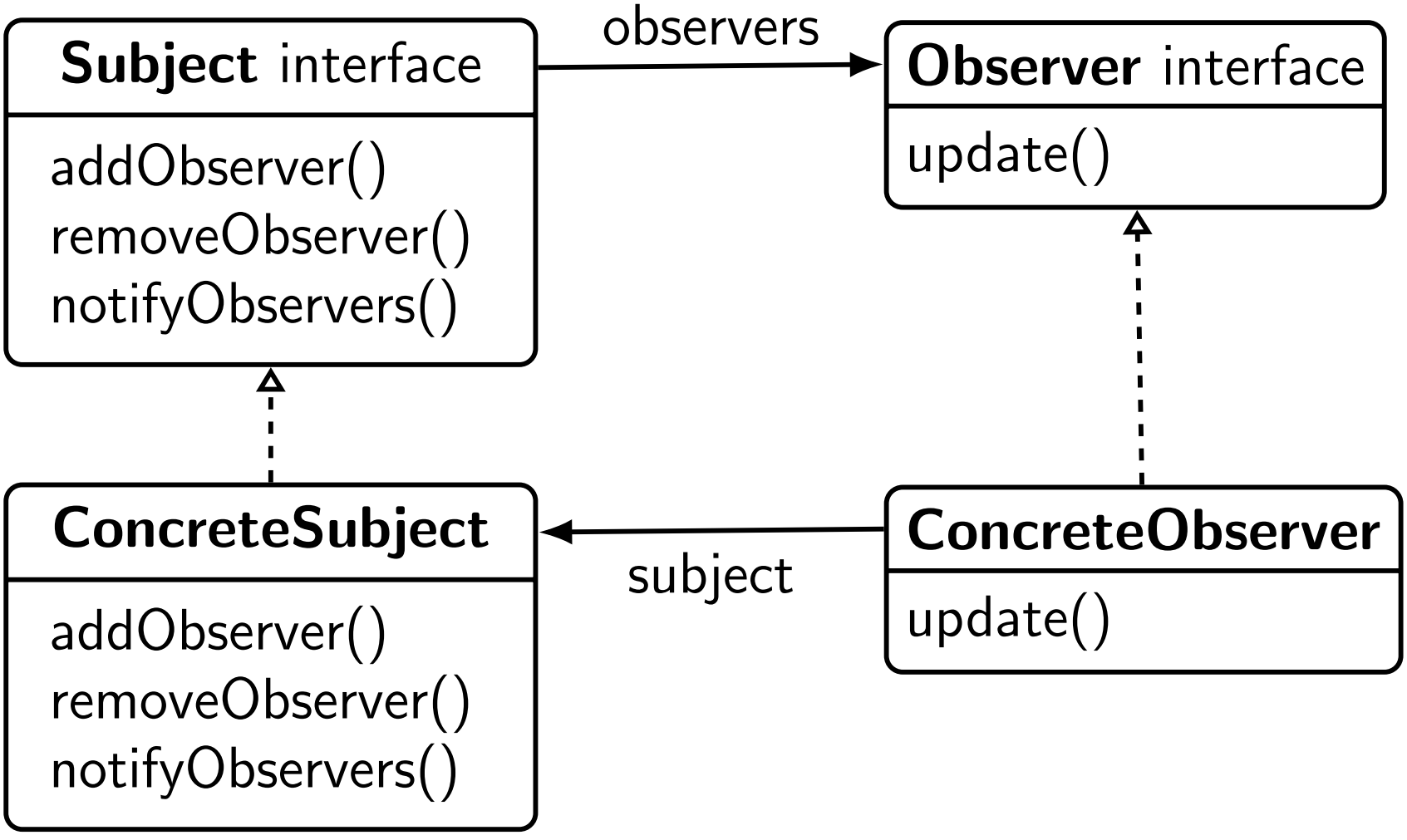
- Just like newspapers and magazines
  - email lists
  - RSS feeds
  - following someone on Twitter
- You subscribe and receive any new additions
- You unsubscribe and stop receiving anything



The Observer Pattern

The Observer Pattern defines a one-to-many dependency between objects so that when one object changes state, all its dependences are notified and updated automatically.

The Observer Pattern



The Observer Pattern

- Objects use the `Subject` interface to (de)register as observers
- Each subject can have many observers
- All potential observers need to implement the `Observer` interface and provide the `update()` method
- A concrete subject always implements the `Subject` interface and the `notifyObservers()` method
- Concrete observers can be any class that implements the `Observer` interface and registers with a concrete subject

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- We can reuse subjects or observers independently of each other
- Changes to either the subject or an observer will not affect each other
- **Loosely coupled designs allow us to build flexible OO systems that can handle change because they minimize the interdependencies between objects.**

Weather Data Interfaces

```
public interface Subject {
  public void registerObserver(Observer o);
  public void removeObserver(Observer o);
  public void notifyObservers();
}
```

```
public interface Observer {
  public void update(float temp,
                     float humidity,
                     float pressure);
}
```

```
public interface DisplayElement {
  public void display();
}
```

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What's wrong here?

```
public interface DisplayElement {
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Adding an interface for all display types.

Implementing the Subject Interface

```
public class WeatherData implements Subject {
  private List<Observer> observers;
  private float temperature;
  private float humidity;
  private float pressure;

  public WeatherData() {
    observers = new ArrayList<>();
  }

  public void registerObserver(Observer o) {
    observers.add(o);
  }

  public void removeObserver(Observer o) {
    observers.remove(o);
  }
```

Notify Methods

```
public void notifyObservers() {
  for(Observer observer : observers) {
    observer.update(temperature, humidity, pressure);
  }
}

public void measurementsChanged() {
  notifyObservers();
}
```

A Display Element

```
public class CurrentConditionsDisplay
    implements Observer, DisplayElement {

  private float temperature;
  private float humidity;
  private Subject weatherData;

  public CurrentConditionsDisplay(Subject weatherData) {
    this.weatherData = weatherData;
    weatherData.registerObserver(this);
  }

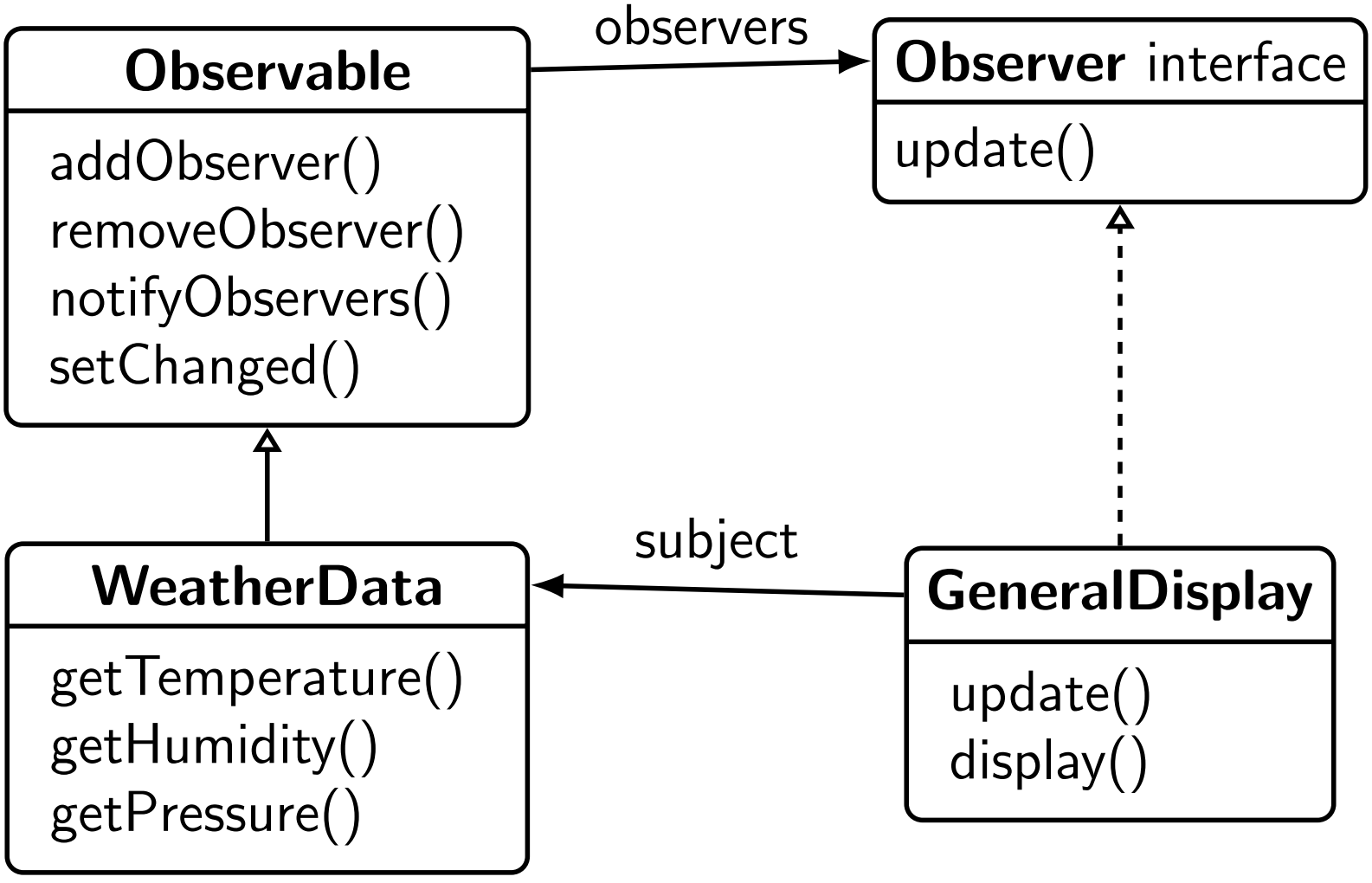
  public void update(float temp, float humidity, float pressure) {
    this.temperature = temp;
    this.humidity = humidity;
    display();
  }

  public void display() {
    System.out.println("Current conditions: " + temperature
                + "F degrees and " + humidity + "% humidity");
  }
}
```

Java's Built-In Observer Pattern

- Java provides the `Observer` interface and the `Observable` class in the package `java.util`
  - Similar to `Subject` and `Observer`
  - Must *extend* `Observable` rather than *implement* `Subject`

Another Design...



The Java Observer Pattern

For an object to become an observer

- Just implement the `Observer` interface (as before)

For the observable to send notifications

- Become observable by *extending* the `java.util.Observable` superclass
- Call the `setChanged()` method to signify that the state of the object has changed
- Call one of two notification methods:
  - `notifyObservers()`
  - `notifyObservers(Object arg)`

The Dark Side of Java Observables

- Observable is a class, not an interface
  - You have to subclass it, so you can't add the Observable behavior onto a class that already extends something else
    - Limits reuse potential
  - Because there's no Observable interface, you cannot create your own implementations of Observables
- Observable protects crucial methods
  - E.g., setChanged() can only be called by subclasses
  - Limits flexibility; you cannot favor composition over inheritance

Should I Use Java Observables?

- **NO**
- Java's Observable library was deprecated in Java 9
- This does not mean that the observer pattern is deprecated just that this particular implementation is
- What should you use instead?
- You can roll your own implementation to have more flexibility and control.
- Use PropertyChangeSupport/Listener from java.beans

What is a bean?

- Just a standard describing a class that has the following properties:
  - All properties are private
  - Has a public no argument constructor
  - Implements Serializable