

# Observer

CSCI 4448/5448: Object-Oriented Analysis & Design

Lecture 12

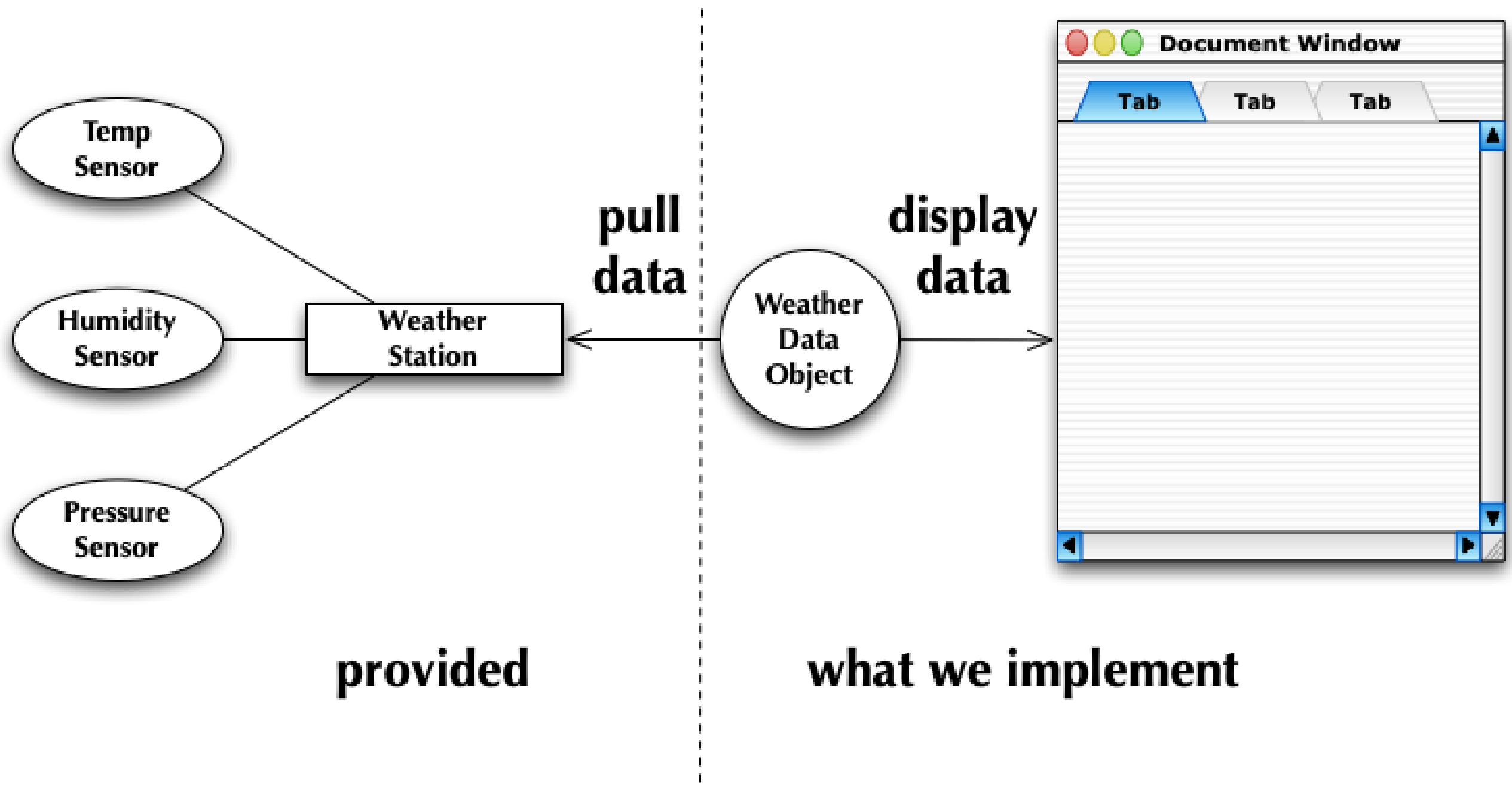
# Acknowledgement & Materials Copyright

- I'd like to start by acknowledging Dr. Ken Anderson
- Ken is a Professor and the Chair of the Department of Computer Science
- Ken taught OOAD on several occasions, and has graciously allowed me to use his copyrighted material for this instance of the class
- Although I will modify the materials to update and personalize this class, the original materials this class is based on are all copyrighted © Kenneth M. Anderson; the materials are used with his consent; and this use in no way challenges his copyright

# Observer Pattern

- Don't miss out when something interesting (in your system) happens!
  - The observer pattern allows objects to keep other objects informed about events occurring within a software system (or across multiple systems)
  - It's dynamic in that an object can choose to receive or not receive notifications at run-time
  - Observer happens to be one of the most heavily used patterns in the Java Development Kit
  - and indeed is present in many other frameworks

# Weather Monitoring



We need to pull information from a weather station and then generate “current conditions, weather stats, and a weather forecast”.

# WeatherData Skeleton

<b>WeatherData</b>
<code>getTemperature()</code>
<code>getHumidity()</code>
<code>getPressure()</code>
<code>measurementsChanged()</code>

We receive a partial implementation of the WeatherData class from our client.

They provide three getter methods for the sensor values and an empty `measurementsChanged()` method that is guaranteed to be called whenever a sensor provides a new value

We need to pass these values to our three displays... simple!

# First pass at measurementsChanged

```
1  ...
2
3  public void measurementsChanged() {
4
5      float temp      = getTemperature();
6      float humidity = getHumidity();
7      float pressure = getPressure();
8
9      currentConditionsDisplay.update(temp, humidity, pressure);
10     statisticsDisplay.update(temp, humidity, pressure);
11     forecastDisplay.update(temp, humidity, pressure);
12
13 }
14
15 ...
16
```

1. The number and type of displays may vary. These three displays are hard coded with no easy way to update them.

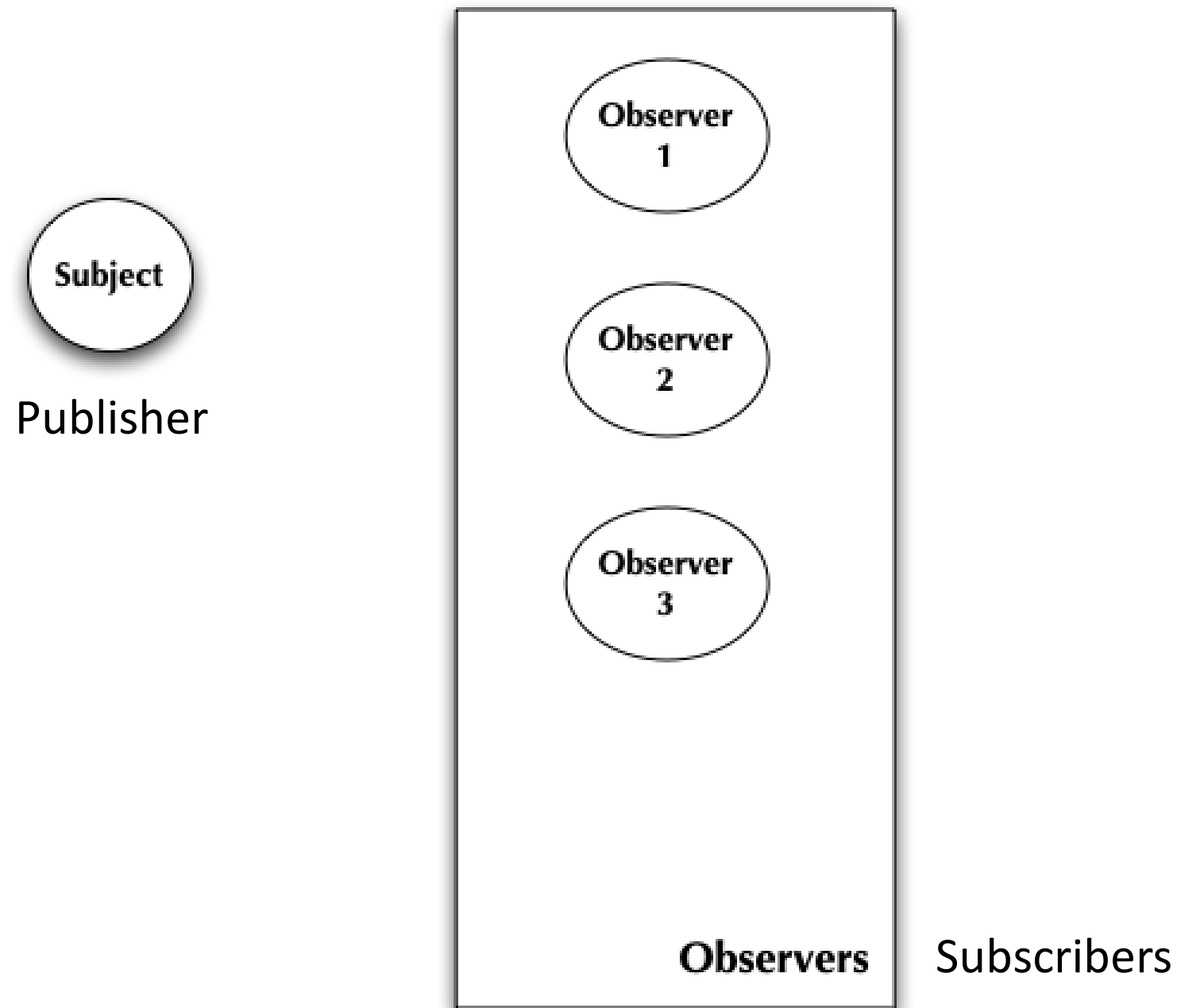
## Problems?

2. Coding to **implementations**, not an **interface**! Each implementation has adopted the same interface, so this will make translation easy!

# Observer Pattern

- This situation can benefit from use of the observer pattern
- This pattern is similar to subscribing to a newspaper
  - A newspaper comes into existence and starts publishing editions
  - You become interested in the newspaper and subscribe to it
  - Any time an edition becomes available, you are notified (by the fact that it is delivered to you)
  - When you don't want the paper anymore, you unsubscribe
  - The newspaper's current set of subscribers can change at any time
- Observer is just like this but we call the publisher the "subject" and we refer to subscribers as "observers"
- Observer can also be considered a broadcaster, since the publisher is going to send messages out regardless of who subscribes

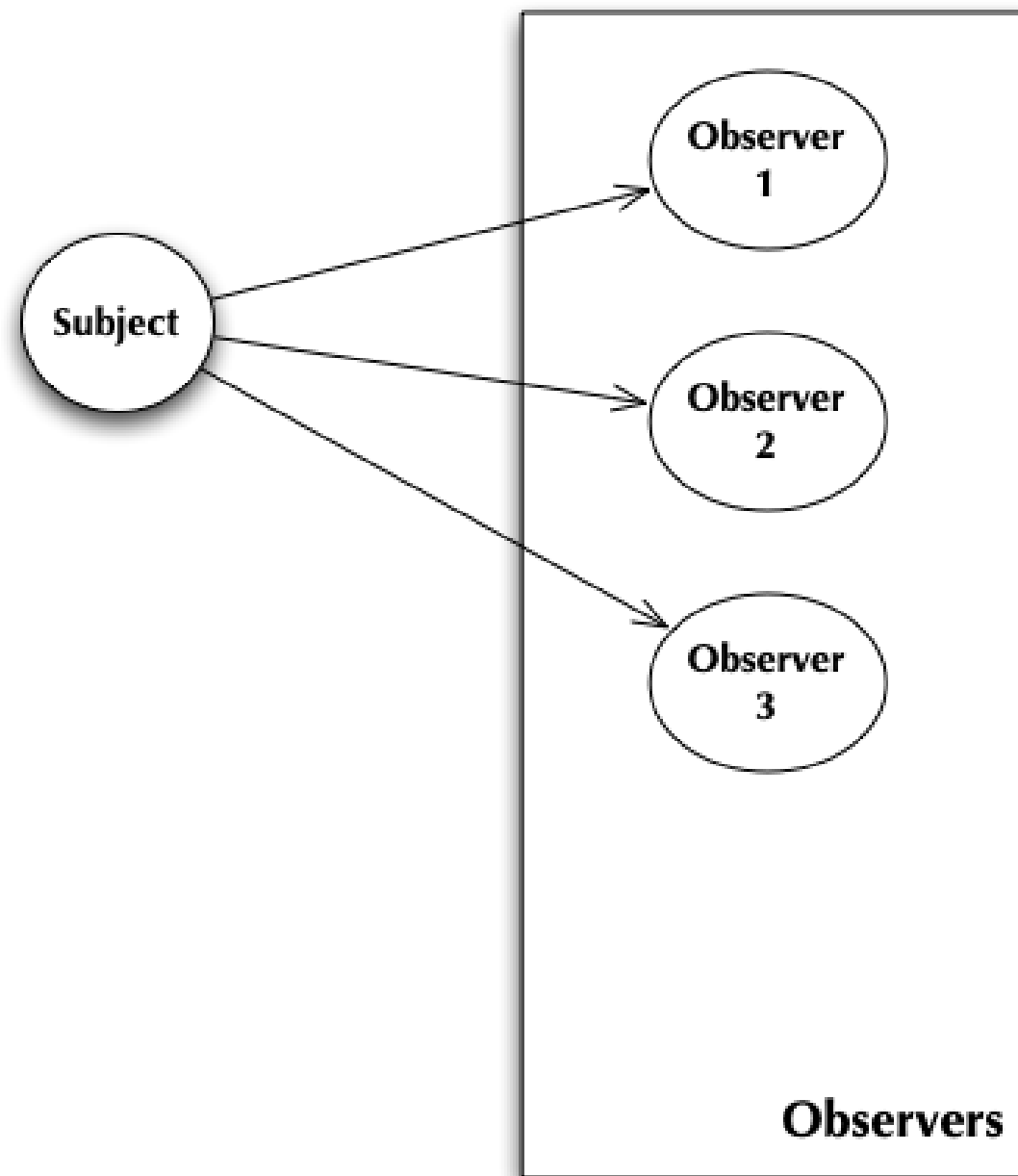
# Observer in Action (I)



**Subject maintains a list of observers**

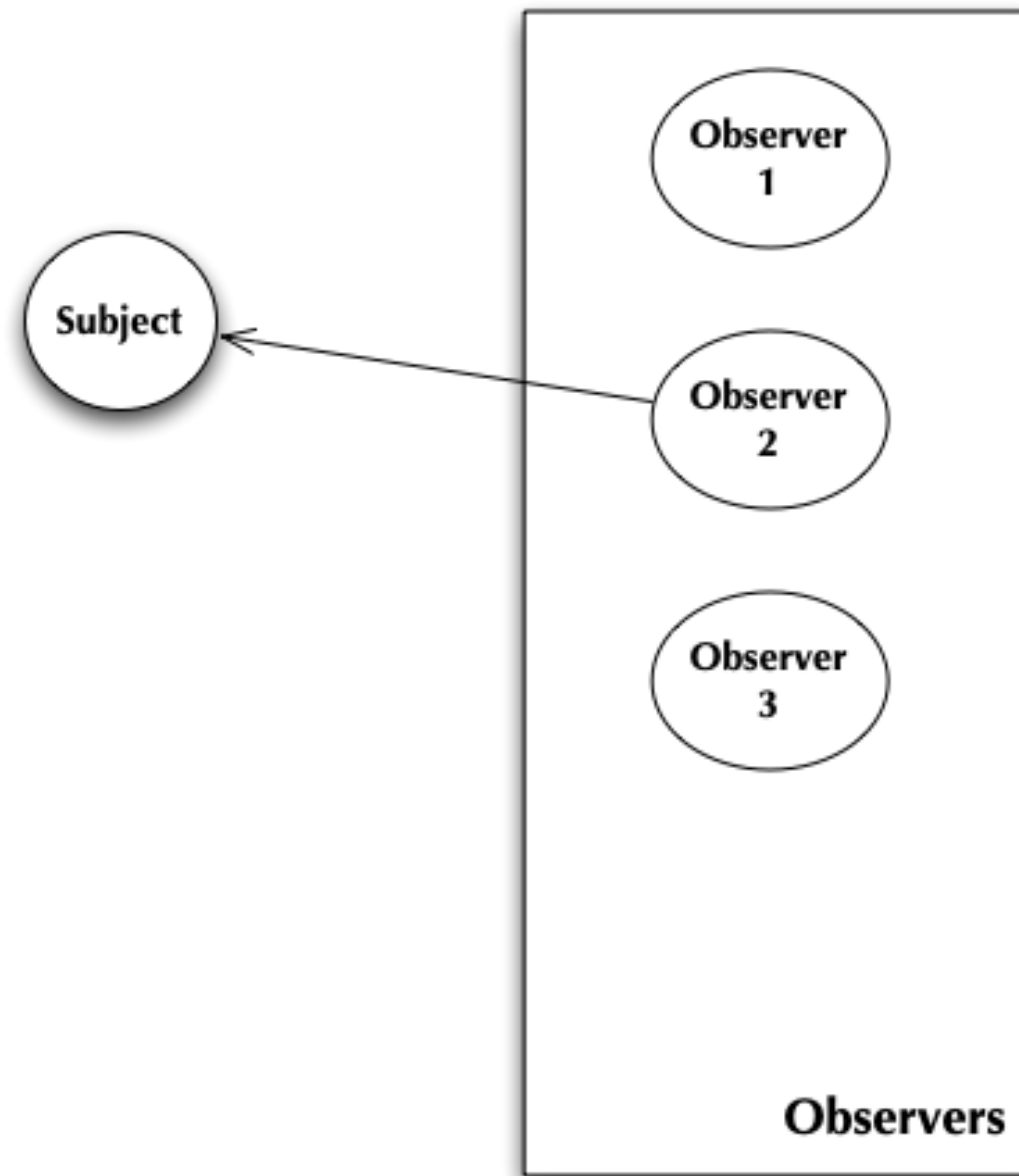


# Observer in Action (II)



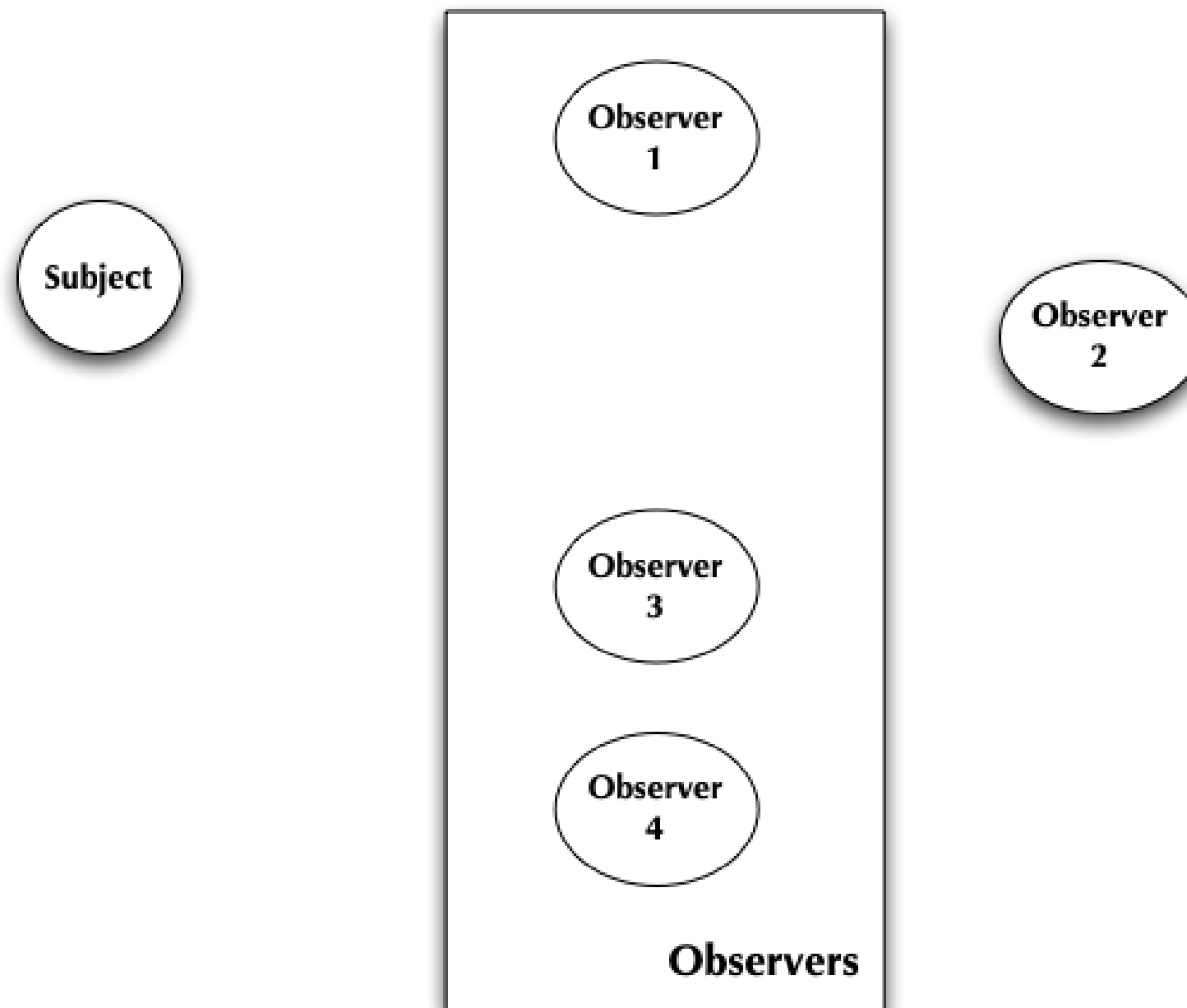
**If the Subject changes, it notifies its observers**

# Observer in Action (III)



**If needed, an observer may query its subject for more information**

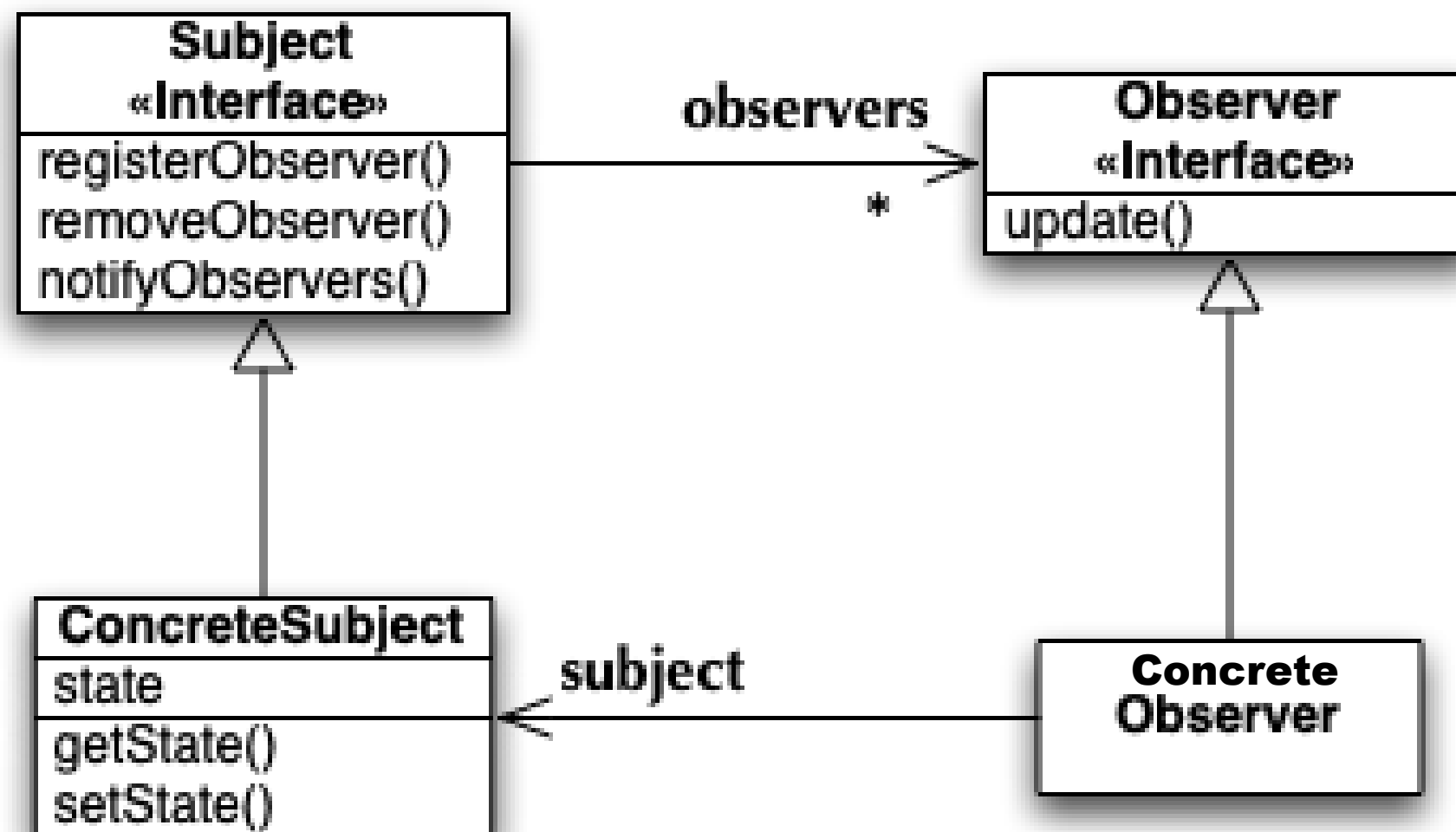
# Observer In Action (IV)



**At any point, an observer may join or leave the set of observers**

# Observer Definition and Structure

- The Observer Pattern defines a one-to-many dependency between a set of objects, such that when one object (the subject/publisher) changes, all of its dependents (observers/subscribers) are notified and updated automatically



# Observer Benefits

- Observer affords a loosely coupled interaction between subject and observer
  - This means they can interact with very little knowledge about each other
- Consider
  - The subject only knows that observers implement the Observer interface
    - We can add/remove observers of any type at any time
    - We never have to modify subject to add a new type of observer
  - We can reuse subjects and observers in other contexts
    - The interfaces plug-and-play anywhere observer is used
  - Observers may have to know about the ConcreteSubject class if it provides many different state-related methods
    - Otherwise, data can be passed to observers via the update() method
- Note: The textbook includes a full Java build out of the weather station...

# Concerns for Observers

- Keep clarity in the design about why notifications will happen
  - Knowing why notices occur will help in design of observer logic
- Dealing with unexpected updates
  - Observers and observed objects have no knowledge of each other's state or existence
  - A seemingly simple subject change may cause a cascade of updates to observers and all their dependent objects
  - When dependency criteria is not well-defined or maintained, spurious or unexpected updates can cause issues, which may be hard to track down
- Overly simple connectivity?
  - In the base form of the simple update protocol, no details are provided on what changed in the subject
  - Without additional protocol details to help observers discover what changed, they may be forced to work to discover what the subject changes were
- Push or Pull?
  - Including detailed information about changes in notifications is a “push” model
  - Having the observers look for or query for what changed is a “pull” model

<http://www.cs.unc.edu/~stotts/GOF/hires/pat5gfso.htm>

# Observers ~~are~~ were built in for Java, but...

- Using `java.util.Observable` and `java.util.Observer`
  - `Observer` is an interface with one defined method: `update(subject, data)`
  - To notify observers: call `setChanged()`, then `notifyObservers(data)`
  - `Observable` is a CLASS, a subject has to subclass it to manage observers
    - This is an issue, because we can only inherit it, nothing else – reduces its usefulness
    - Also, since it's not an interface, there's not much you can do to make a custom version
    - This is actually trouble for two principles
      - Coding to an interface, not an implementation
      - Favor composition over inheritance
      - We'll talk about the resulting issues with this approach...
- <https://docs.oracle.com/javase/8/docs/api/index.html?java/util/Observable.html>
- Nice Java example at Javaworld:  
<https://www.javaworld.com/article/2077258/observer-and-observable.html>

# Observers in Java – An Observable

```
import java.util.Observable;
public class ObservableValue extends Observable
{
    private int n = 0;
    public ObservableValue(int n)
    {
        this.n = n;
    }
    public void setValue(int n)
    {
        this.n = n;
        setChanged();
        notifyObservers();
    }
    public int getValue()
    {
        return n;
    }
}
```



# Observers in Java – An Observer

```
import java.util.Observer;
import java.util.Observable;
public class TextObserver implements Observer
{
    private ObservableValue ov = null;
    public TextObserver(ObservableValue ov)
    {
        this.ov = ov;
    }
    public void update(Observable obs, Object obj)
    {
        if (obs == ov)
        {
            System.out.println(ov.getValue());
        }
    }
}
```

# Observers in Java – Tied Together

```
public class Main
{
    public Main()
    {
        ObservableValue ov = new ObservableValue(0);
        TextObserver to = new TextObserver(ov);
        ov.addObserver(to);
    }
    public static void main(String [] args)
    {
        Main m = new Main();
    }
}
```

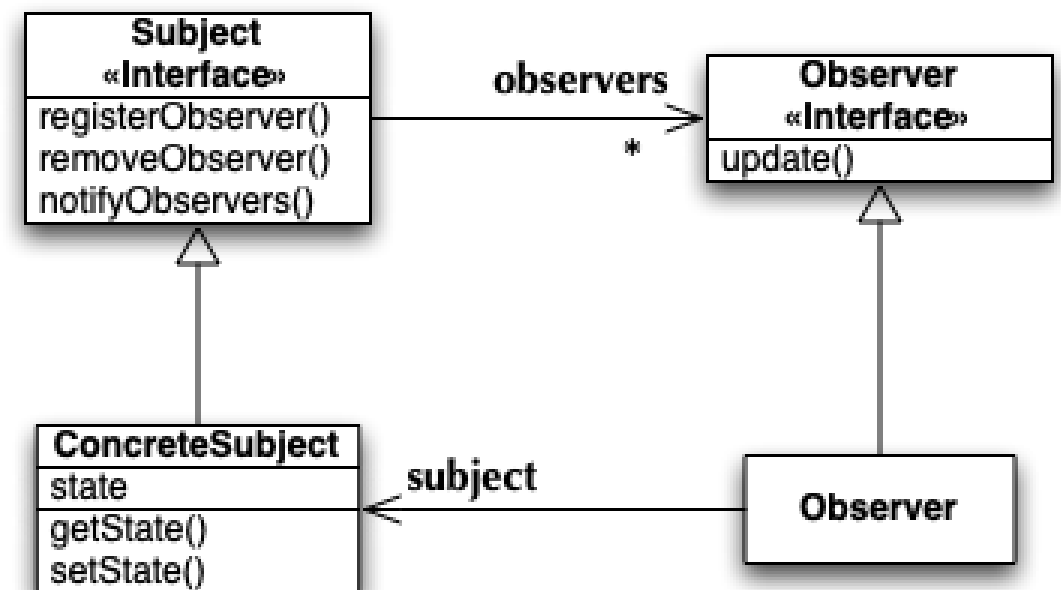
# Now, forget that...

- I wanted to review the Java 8 Observer/Observable because it is a clear implementation of the Observer pattern, but...
- Observer/Observable was depreciated in Java 9
  - Order of notifications provided by Observable not specified
  - Observable is not serializable (we'll talk to that later)
  - Not thread safe
  - And overall, a poor model that was never “fixed”
- Suggested Java Alternatives:
  - Make your own – good example in the textbook
  - java.beans PropertyChangeListener interface (replaces Observer) and PropertyChangeSupport (a class for creating Observable objects)
    - <https://www.baeldung.com/java-observer-pattern>
    - Pretty much a drop in replacement for Observer/Observable)
  - Flow class with 4 interfaces (from java.util.concurrent)
    - Flow.Publisher – for making something observable
    - Flow.Subscriber – for making something observe events
    - Flow.Processor – component that supports both Subscribe and Publish
    - Flow.Subscription – used to link Publishers and Subscribers
    - <https://docs.oracle.com/javase/9/docs/api/java/util/concurrent/Flow.html>
  - Observer/Observable would be usable for classwork if you drop back to Java 8/9, but I'd look at these methods instead
- Full discussion here: <https://stackoverflow.com/questions/46380073/observer-is-deprecated-in-java-9-what-should-we-use-instead-of-it>

# You could... Write your own Observer, Observable interfaces

- Observer (Subscriber)

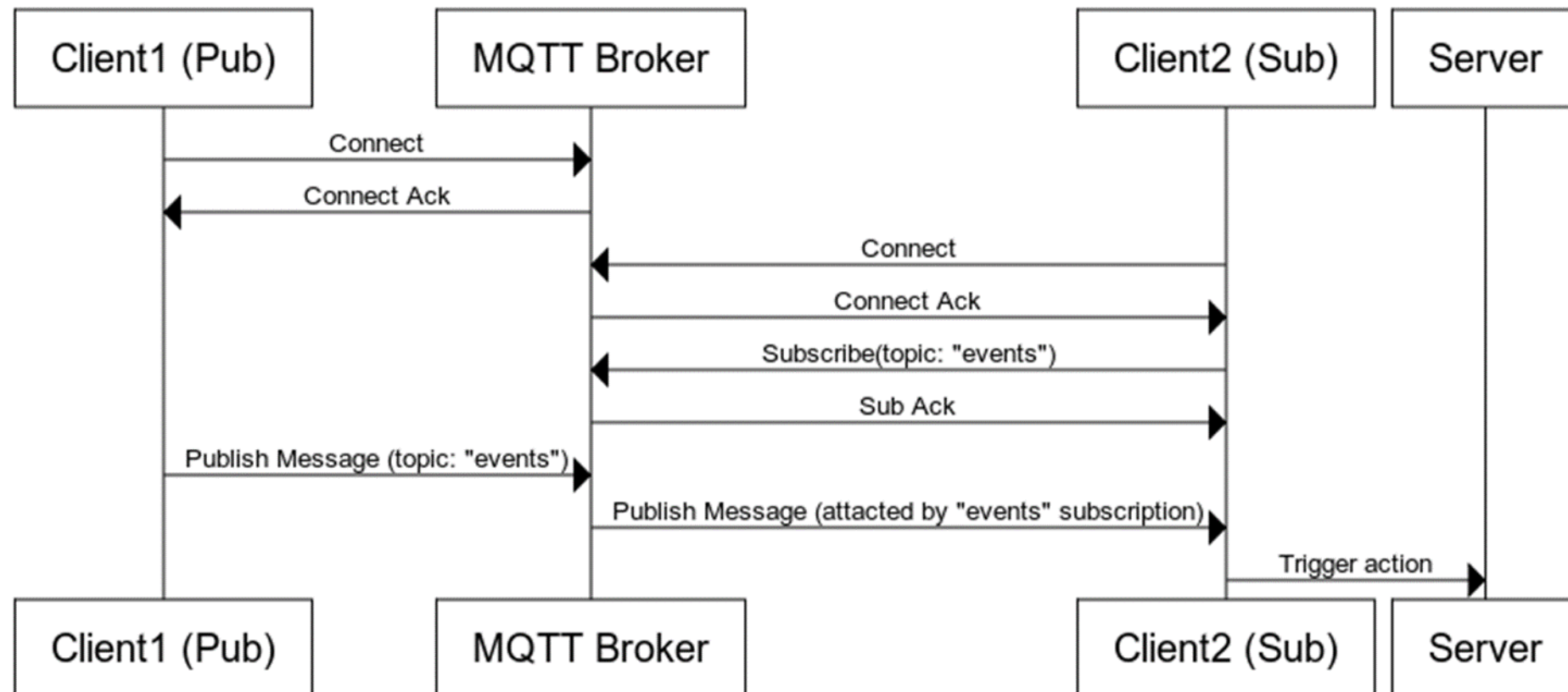
- Register with any observable you want information from
- Provide an update() method to get notified if things change
- Call the Observable's getState() method to get the changed information



- Observables (Publishers/Subjects)

- Allow register and remove observer objects
- Call notifyObservers update() methods when something happens
- Allow for get and set of state; getState will be called by Observers

# You could... Use another Pub/Sub model (analogous to Observed/Observer)



- We saw this model in the UML lecture:
  - <https://stackoverflow.com/questions/32538535/node-and-mqtt-do-something-on-message>
- You can use an MQTT broker with Java from a standard message queuing app like RabbitMQ; or you can use other pub/sub approaches from a socket library like ZeroMQ (more later on these in the Proxy pattern lecture...)

# Python - Observer

In this example of using Observer, we're using Python classes to set up the plumbing for an Observable class and an Observer class.

This could be done with abstract classes as well to prevent any mistaken direct instantiations...

```
# Subject aka Observable or Publisher
class Subject:
    def register_observer(self, observer):
        raise NotImplementedError

    def remove_observer(self, observer):
        raise NotImplementedError

    def notify_observers(self):
        raise NotImplementedError

# Observer aka Subscriber
class Observer:
    def update(self, temp):
        raise NotImplementedError
```

Example from:

[https://github.com/jtortorelli/head-first-design-patterns-python/blob/master/src/python/chapter\\_2/weather\\_o\\_rama.py](https://github.com/jtortorelli/head-first-design-patterns-python/blob/master/src/python/chapter_2/weather_observer.py)

# Python - Observer

We'll make a weather publisher (observable, subject) by inheriting from Subject and defining methods and local attributes we need.

Note that the Subject here is maintaining a list of observers and functions to add, remove, and notify them.

Whenever temperature is set in `set_measurements`, a changed event causes all registered observers to be notified.

```
# Weather Publisher
```

```
class WeatherData(Subject):
```

```
    def __init__(self):
```

```
        self.temperature = None
```

```
        self.observers = []
```

```
    def register_observer(self, observer):
```

```
        self.observers.append(observer)
```

```
    def remove_observer(self, observer):
```

```
        self.observers.remove(observer)
```

```
    def notify_observers(self):
```

```
        for observer in self.observers:
```

```
            observer.update(self.temperature)
```

```
    def measurements_changed(self):
```

```
        self.notify_observers()
```

```
    def set_measurements(self, temperature):
```

```
        self.temperature = temperature
```

```
        self.measurements_changed()
```

Example from:

[https://github.com/jtortorelli/head-first-design-patterns-python/blob/master/src/python/chapter\\_2/weather\\_o\\_rama.py](https://github.com/jtortorelli/head-first-design-patterns-python/blob/master/src/python/chapter_2/weather_observer.py)

# Python - Observer

When we make the Observer or Subscriber, we get a reference to the Publisher – here the WeatherData object – and we register ourselves for updates.

Now, whenever the WeatherData object changes, we'll be notified and we'll do what we want with the new data (in this case, display it).

Here we plumbed this out ourselves, you might grab a library for this instead, like PyPubSub (<https://pypi.org/project/PyPubSub/>)

```
# Weather Subscriber
class CurrentConditionsDisplay(Observer):
    def __init__(self, weather_data):
        self.weather_data = weather_data
        self.weather_data.register_observer(self)
        self.temperature = None

    def update(self, temp):
        self.temperature = temp
        self.display()

    def display(self):
        print(f"Current conditions: {self.temperature} F")

# Main program
wd = WeatherData()
ccd = CurrentConditionsDisplay(wd)

wd.set_measurements(80)
wd.set_measurements(82)
wd.set_measurements(78)
```

Example from:

[https://github.com/jtortorelli/head-first-design-patterns-python/blob/master/src/python/chapter\\_2/weather\\_o\\_rama.py](https://github.com/jtortorelli/head-first-design-patterns-python/blob/master/src/python/chapter_2/weather_observer.py)



# Summary

- Observer provides a one-to-many dependency; when one object changes state, all the dependents are automatically notified.
- It is one of the most popular patterns from the GoF patterns library
- It helps keep **Loose Coupling** between objects; able to notify other objects about changes without knowing about them
- Design Principle: **Strive for loosely coupled designs between objects that interact**
- The Java 8 Observer/Observable implementation will work, but it has issues and was depreciated in Java 9
- It's straightforward to use a simple custom implementation (see the textbook)
- Other options for Java are either `PropertyChangeListener` interface (replaces `Observer`) and `PropertyChangeSupport` (a class for creating `Observable` objects) or the interfaces from the `Flow` class (from `java.util.concurrent`)
- In Python, you can also easily develop an observer/observable or use a library like `PyPubSub`

# Next Steps

All staff now providing office hours:  
Office hours are posted in Canvas  
Announcements and Piazza posts

- Latest
  - Stop by and meet Sudarshan Sridhar ([susr2424@colorado.edu](mailto:susr2424@colorado.edu))
    - Updates for Sudarshan's hours and contact info soon
  - Put some work in on Project 2, you'll be using the code and UML for two more projects...
  - Class exercise Monday morning...
- Assignments
  - New Piazza participation topic this week, keep up to get those 100 points!
  - Project 2 is up on Canvas – for your two-person team!
    - Part 1 (UML and OO questions) is due today Wed 9/14
    - Part 2 (code submission) is due after that on Wed 9/21
  - Opening up Project 3 on Wed 9/21
  - New Quiz 3 opened on Sat 9/17, due Thur 9/22
  - Graduate Research Project team topics are being reviewed, next up is the Outline due Fri 9/30
- Make sure you're getting Piazza and Canvas notifications
- Coming up
  - Next up: OO patterns and principles – Decorator, a design problem to consider, Factory patterns
  - Head First Design Patterns Textbook: Chap. 1 is Pattern/Strategy intro, Chap. 2 is Observer, Chap. 3 is Decorator – review as needed for different perspectives and descriptions – plus full(er) code examples
  - All textbook code examples are at <https://github.com/bethrobson/Head-First-Design-Patterns>
- Please come find us for any help you need or questions you have!