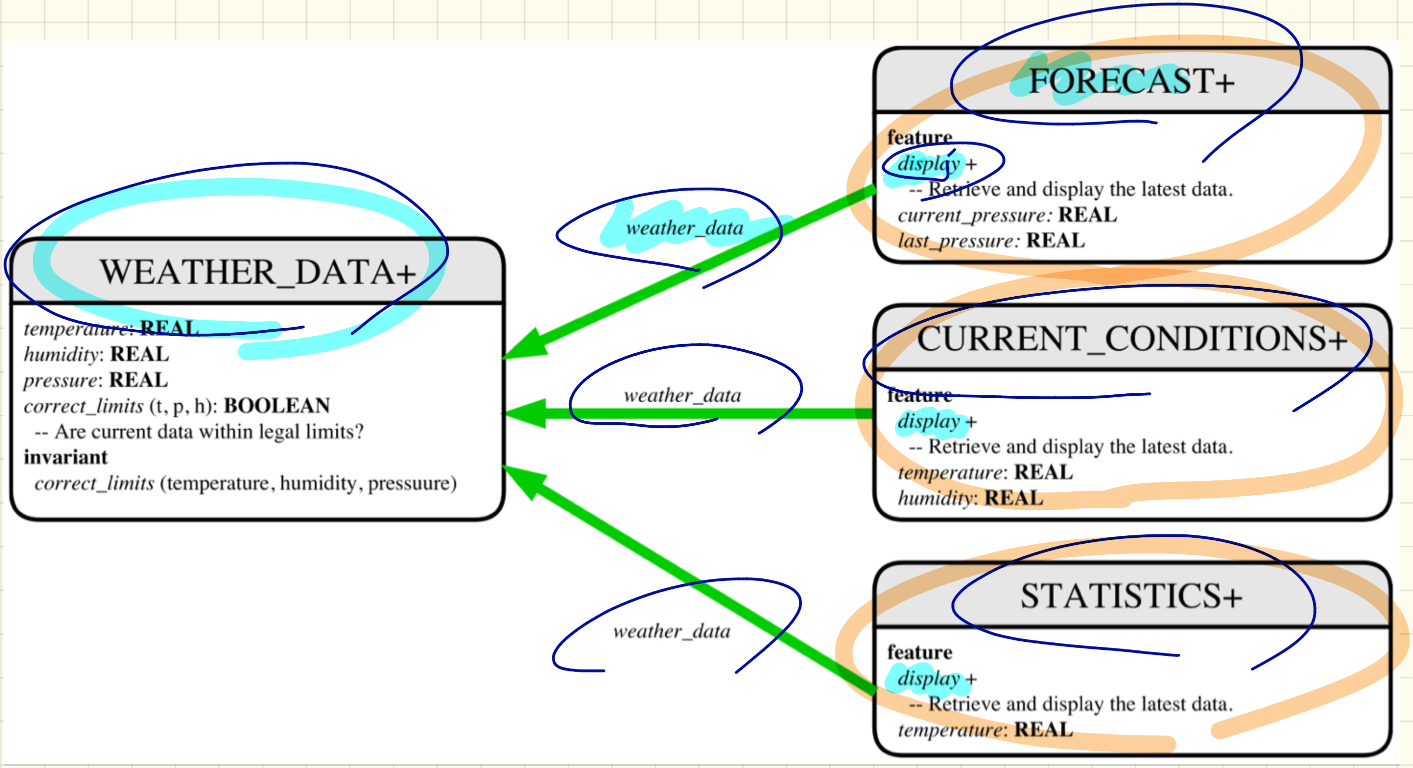
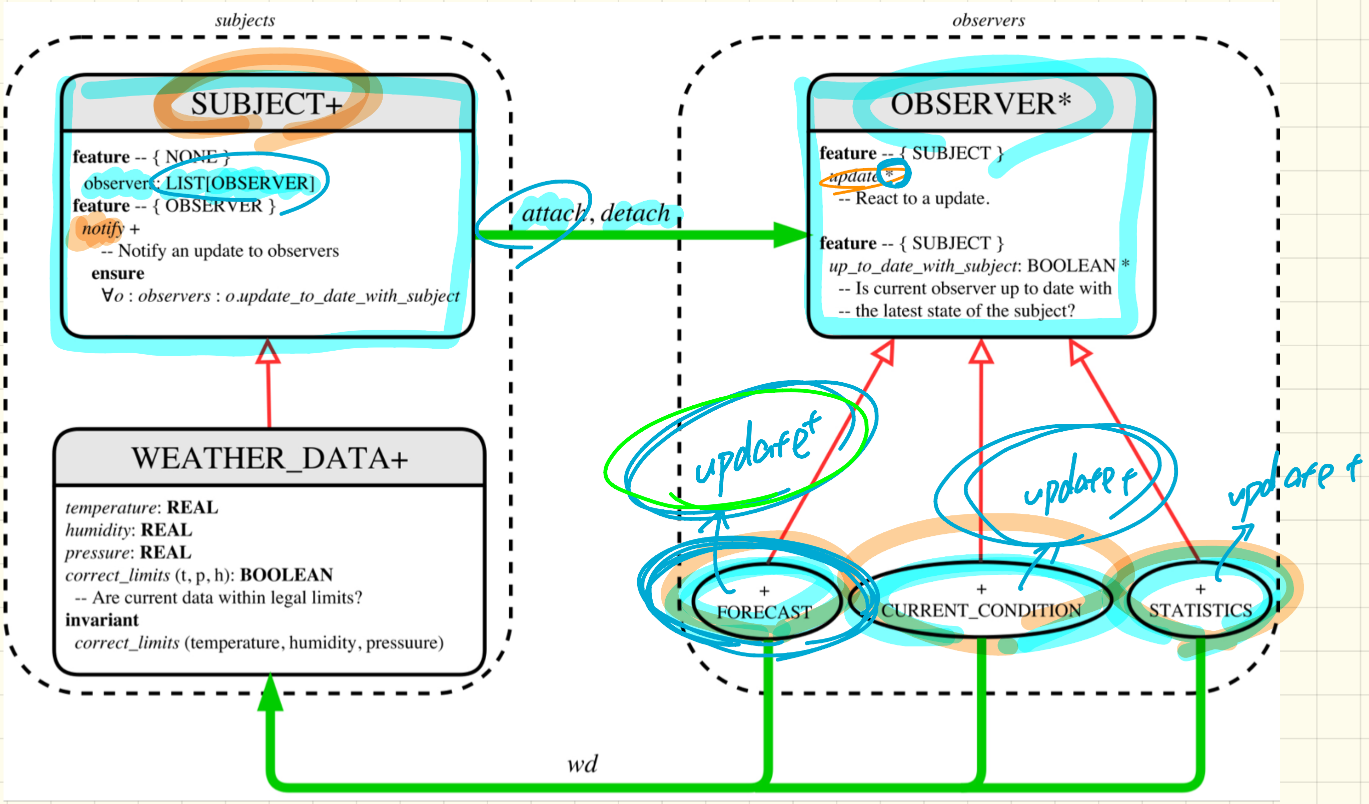
Wednesday March 27

Lecture 21

Weather Station: 1st Design



Weather Station: Applying the Observer Pattern



subjects
observers
SUBJECT+
feature -- { NONE }
observers: LIST[OBSERVER]
feature -- { OBSERVER }
notify +
-- Notify an update to observers
ensure
∀o : observers : o.update_to_date_with_subject
attach, detach
OBSERVER*
feature -- { SUBJECT }
update *
-- React to a update.
feature -- { SUBJECT }
up_to_date_with_subject: BOOLEAN *
-- Is current observer up to date with
-- the latest state of the subject?
WEATHER_DATA+
temperature: REAL
humidity: REAL
pressure: REAL
correct_limits (t, p, h): BOOLEAN
-- Are current data within legal limits?
invariant
correct_limits (temperature, humidity, pressuure)
+ FORECAST
+ CURRENT_CONDITION
+ STATISTICS
update+
update+
update+
wd

Implementing Weather Station: Subject

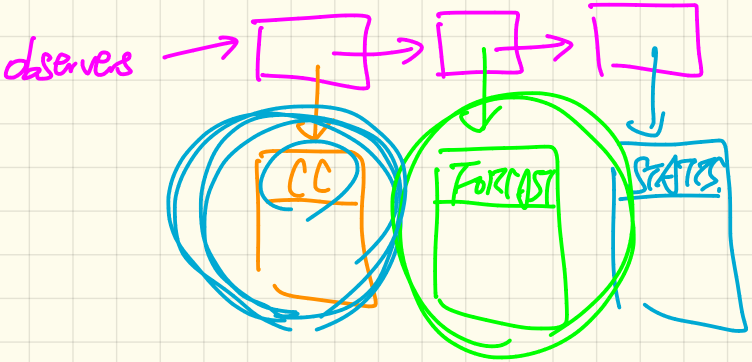
```
class SUBJECT create make
feature -- Attributes
  observers : LIST[OBSERVER]
feature -- Commands
  make
   do create {LINKED_LIST[OBSERVER]} observers.make
   ensure no_observers:  observers.count = 0 end
feature -- Invoked by an OBSERVER
  attach (o: OBSERVER) -- Add 'o' to the observers
    require not_yet_attached: not observers.has (o)
    ensure is_attached: observers.has (o) end
  detach (o: OBSERVER) -- Add 'o' to the observers
    require currently_attached: observers.has (o)
    ensure is_attached: not observers.has (o) end
feature -- invoked by a SUBJECT
  notify -- Notify each attached observer about the update.
    do across observers as cursor loop cursor.item.update end
    ensure all_views_updated:
      across observers as o all o.item.up_to_date_with_subject end
    end
end
```

OBSERVER

→ declared at OBSERVER

```
class WEATHER_DATA
inherit SUBJECT  rename make as make_subject end
create make
feature -- data available to observers
  temperature: REAL
  humidity: REAL
  pressure: REAL
  correct_limits(t,p,h: REAL): BOOLEAN
feature -- Initialization
  make (t, p, h: REAL)
    do
      make_subject -- initialize empty observers
      set_measurements (t, p, h)
    end
feature -- Called by weather station
  set_measurements(t, p, h: REAL)
    require correct_limits(t,p,h)
invariant
  correct_limits(temperature, pressure, humidity)
end
```

notify.



Implementing Weather Station: Observers

```
deferred class
  OBSERVER
feature -- To be effected by a descendant
  up_to_date_with_subject: BOOLEAN
      -- Is this observer up to date with its subject?
    deferred
    end

  update
      -- Update the observer's view of 's'
    deferred
    ensure
      up_to_date_with_subject: up_to_date_with_subject
    end
end
```

```
class FORECAST
inherit OBSERVER
feature -- Commands
  make(a_weather_data: WEATHER_DATA)
    do weather_data := a_weather_data
       weather_data.attach (Current)
    ensure weather_data = a_weather_data
           weather_data.observers.has (Current)
    end
feature -- Queries
  up_to_date_with_subject: BOOLEAN
    ensure then
      Result = current_pressure = weather_data.pressure
  update
    do -- Same as 1st design; Called only on demand
    end
```

```
class CURRENT_CONDITIONS
inherit OBSERVER
feature -- Commands
  make(a_weather_data: WEATHER_DATA)
    do weather_data := a_weather_data
       weather_data.attach (Current)
    ensure weather_data = a_weather_data
           weather_data.observers.has (Current)
    end
feature -- Queries
  up_to_date_with_subject: BOOLEAN
    ensure then Result = temperature = weather_data.temperature and
                         humidity = weather_data.humidity
  update
    do -- Same as 1st design; Called only on demand
    end
```

```
class STATISTICS
inherit OBSERVER
feature -- Commands
  make(a_weather_data: WEATHER_DATA)
    do weather_data := a_weather_data
       weather_data.attach (Current)
    ensure weather_data = a_weather_data
           weather_data.observers.has (Current)
    end
feature -- Queries
  up_to_date_with_subject: BOOLEAN
    ensure then
      Result = current_temperature = weather_data.temperature
  update
    do -- Same as 1st design; Called only on demand
    end
```

Weather Station: Testing the Observer Pattern

```
class WEATHER_STATION create make
feature -- Attributes
  cc: CURRENT_CONDITIONS ; fd: FORECAST ; sd: STATISTICS
  wd: WEATHER_DATA
feature -- Commands
  make
    do create wd.make (9, 75, 25)
       create cc.make (wd) ; create fd.make (wd) ; create sd.make(wd)

       wd.set_measurements (15, 60, 30.4)
         wd.notify
       cc.display ; fd.display ; sd.display
       cc.display ; fd.display ; sd.display

       wd.set_measurements (11, 90, 20)
         wd.notify
       cc.display ; fd.display ; sd.display
  end
end
```

wd.notify.

wd.attach(cc)

```
class FORECAST
inherit OBSERVER
feature -- Commands
  make(a_weather_data: WEATHER_DATA)
    do weather_data := a_weather_data
       weather_data.attach (Current)
    ensure weather_data = a_weather_data
       weather_data.observers.has (Current)
    end
```

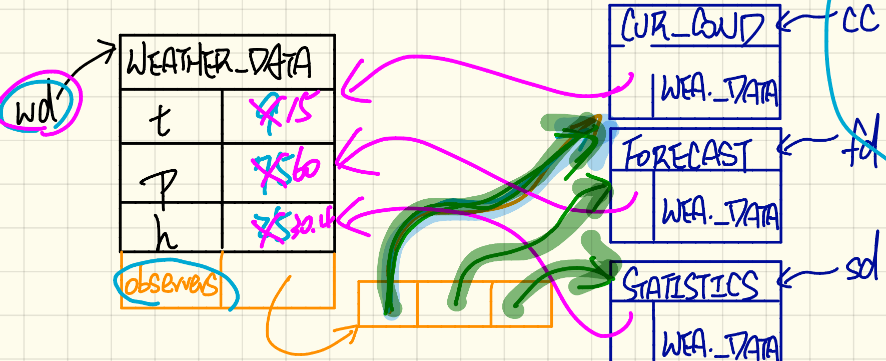
display ~~update~~

```
class CURRENT_CONDITIONS
inherit OBSERVER
feature -- Commands
  make(a_weather_data: WEATHER_DATA)
    do weather_data := a_weather_data
       weather_data.attach (Current)
    ensure weather_data = a_weather_data
       weather_data.observers.has (Current)
    end
```

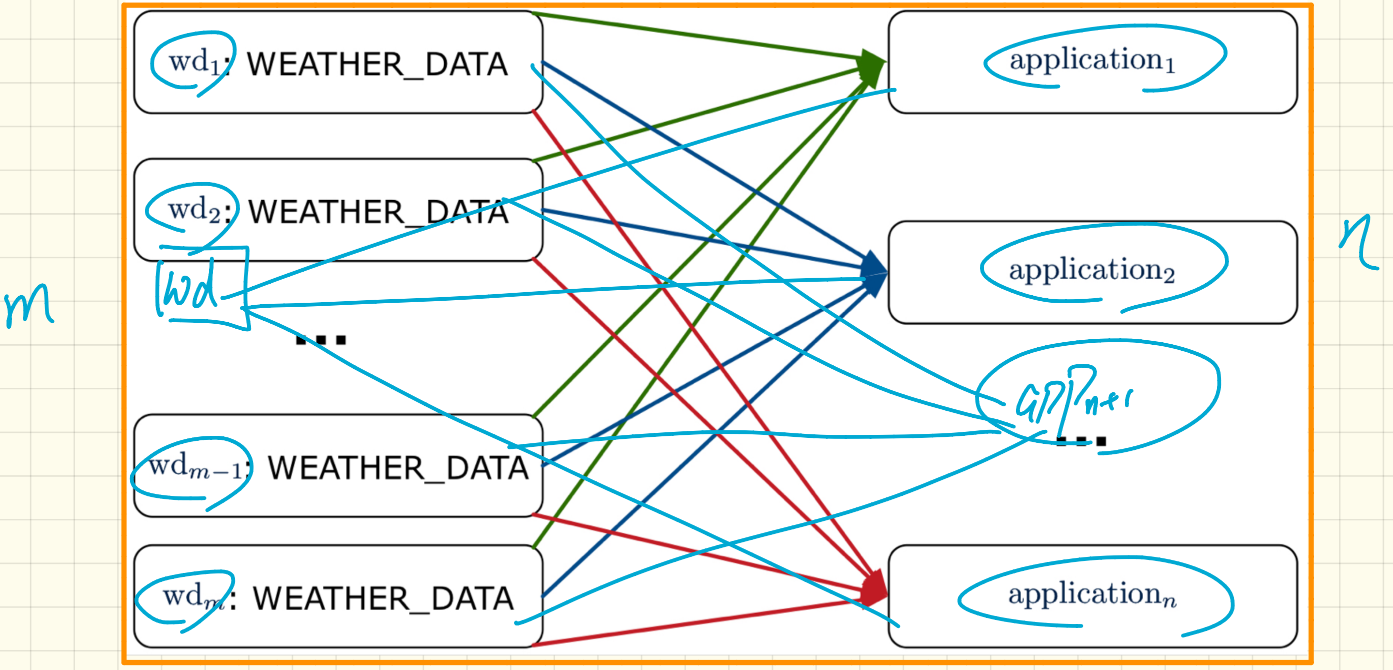
wd wd wd

```
class STATISTICS
inherit OBSERVER
feature -- Commands
  make(a_weather_data: WEATHER_DATA)
    do weather_data := a_weather_data
       weather_data.attach (Current)
    ensure weather_data = a_weather_data
       weather_data.observers.has (Current)
    end
```

a_weather_data.attach(Current)



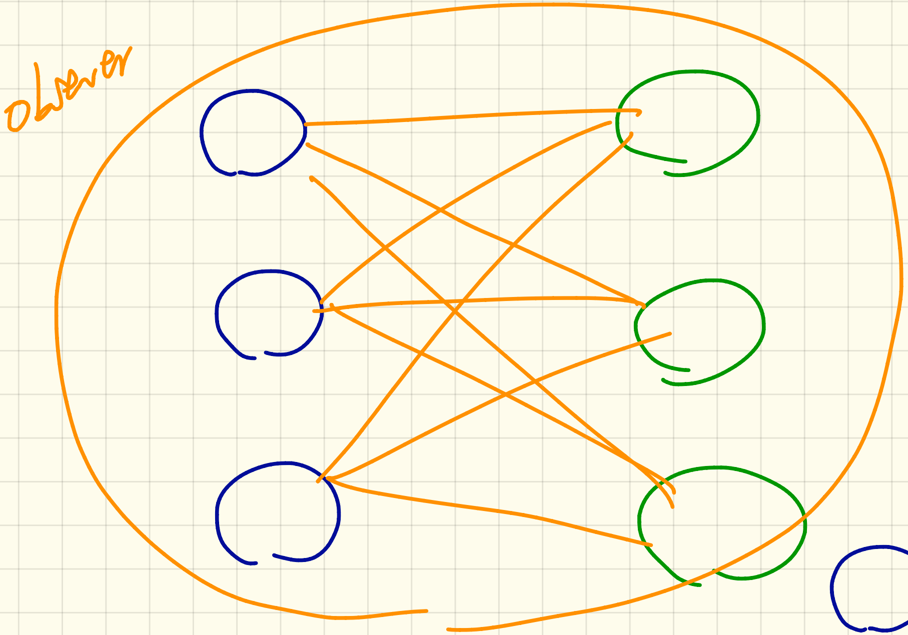
Observer Pattern: Multiple Subjects and Observers

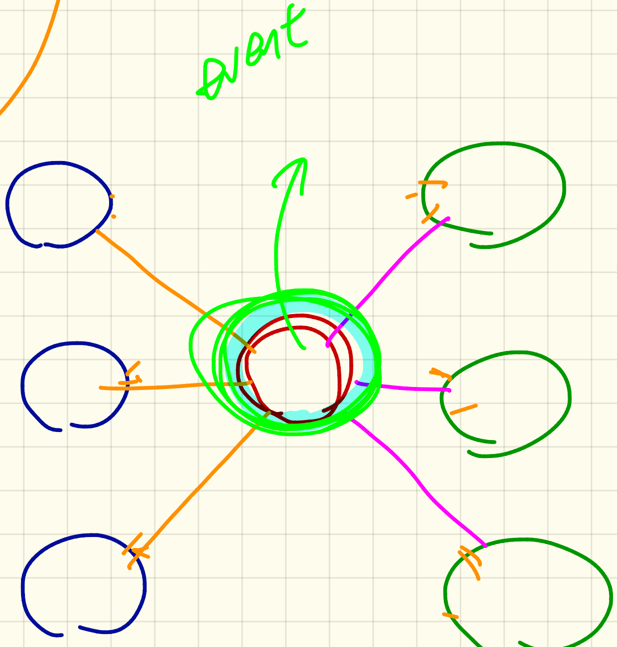


Complexity? $O(m * n)$ ←

Adding a new subject? $O(n)$

Adding a new observer? $O(m)$

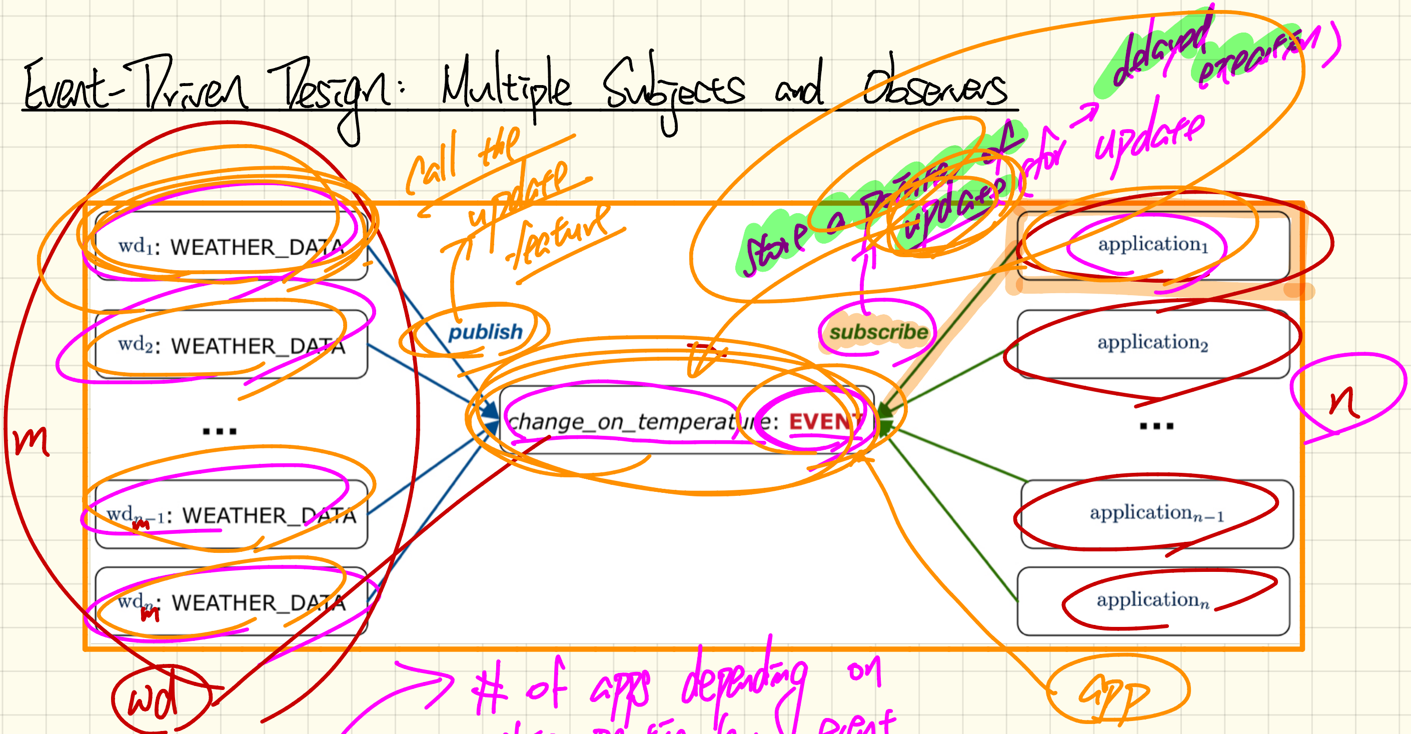




$$\frac{9}{} \text{ vs. } \frac{6}{}$$

$O(m \cdot n)$ $O(m+n)$

Event-Driven Design: Multiple Subjects and Observers



# of apps depending on this particular event

Complexity? $O(m+n)$

Adding a new subject? $O(n)$ $O(n+m)$. $O(1)$

Adding a new observer? $O(1)$

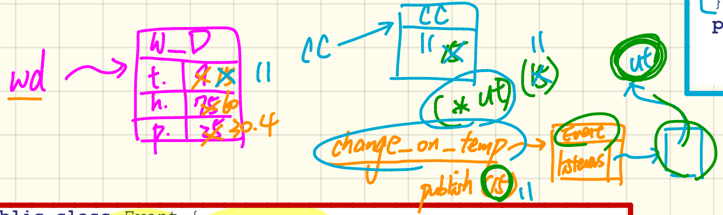
Adding a new event type?

Event-Driven Design in Java

```java
public class WeatherStation {
  public static void main(String[] args) {
    WeatherData wd = new WeatherData(9, 75, 25);
    CurrentConditions cc = new CurrentConditions();
    System.out.println("=======");
    wd.setMeasurements(15, 60, 30.4);
    cc.display();
    System.out.println("=======");
    wd.setMeasurements(11, 90, 20);
    cc.display();
  } }
```

```java
public class CurrentConditions {
  private double temperature; private double humidity;
  public void updateTemperature(double t) { temperature = t; }
  public void updateHumidity(double h) { humidity = h; }
  public CurrentConditions() {
    MethodHandles.Lookup lookup = MethodHandles.lookup();
    try {
      MethodHandle ut = lookup.findVirtual(
        this.getClass(), "updateTemperature",
        MethodType.methodType(void.class, double.class));
      WeatherData.changeOnTemperature.subscribe(this, ut);
      MethodHandle uh = lookup.findVirtual(
        this.getClass(), "updateHumidity",
        MethodType.methodType(void.class, double.class));
      WeatherData.changeOnHumidity.subscribe(this, uh);
    } catch (Exception e) { e.printStackTrace(); }
  }
  public void display() {
    System.out.println("Temperature: " + temperature);
    System.out.println("Humidity: " + humidity); } }
```

agent
update



```java
public class Event {
  Hashtable<Object, MethodHandle> listenersActions;
  Event() { listenersActions = new Hashtable<>(); }
  void subscribe(Object listener, MethodHandle action) {
    listenersActions.put( listener , action );
  }
  void publish(Object arg) {
   for (Object listener : listenersActions.keySet()) {
    MethodHandle action = listenersActions.get(listener);
    try {
      action .invokeWithArguments( listener , arg);
    } catch (Throwable e) { }
   }
  }
}
```

```java
public class WeatherData {
  private double temperature;
  private double pressure;
  private double humidity;
  public WeatherData(double t, double p, double h) {
    setMeasurements(t, h, p);
  }
  public static Event changeOnTemperature = new Event();
  public static Event changeOnHumidity = new Event();
  public static Event changeOnPressure = new Event();
  public void setMeasurements(double t, double h, double p) {
    temperature = t;
    humidity = h;
    pressure = p;
    changeOnTemperature .publish(temperature);
    changeOnHumidity .publish(humidity);
    changeOnPressure .publish(pressure);
  }
}
```

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Event-Driven Design in Eiffel

```
class WEATHER_STATION create make
feature
  cc: CURRENT_CONDITIONS
  make
    do create wd.make (9, 75, 25)
       create cc.make (wd)
       wd.set_measurements (15, 60, 30.4)
       cc.display
       wd.set_measurements (11, 90, 20)
       cc.display
    end
end
```

```
class CURRENT_CONDITIONS
create make
feature -- Initialization
  make(wd: WEATHER_DATA)
    do
      wd.change_on_temperature.subscribe (~~agent~~ update_temperature)
      wd.change_on_temperature.subscribe (agent update_humidity)
    end
feature
  temperature: REAL
  humidity: REAL
  update_temperature (t: REAL) do temperature := t end
  update_humidity (h: REAL) do humidity := h end
  display do ... end
end
```

Command not of type PROCEDURE.

```
class WEATHER_DATA
create make
feature -- Measurements
  temperature: REAL ; humidity: REAL ; pressure: REAL
  correct_limits(t,p,h: REAL): BOOLEAN do ... end
  make (t, p, h: REAL) do ... end
feature -- Event for data changes
  change_on_temperature : EVENT[TUPLE[REAL]]once create Result end
  change_on_humidity : EVENT[TUPLE[REAL]]once create Result end
  change_on_pressure : EVENT[TUPLE[REAL]]once create Result end
feature -- Command
  set_measurements(t, p, h: REAL)
    require correct_limits(t,p,h)
    do temperature := t ; pressure := p ; humidity := h
      change_on_temperature.publish ([t])
      change_on_humidity.publish ([p])
      change_on_pressure.publish ([h])
    end
invariant correct_limits(temperature, pressure, humidity) end
```

when you call the update on observers, it takes one input.

```
class EVENT [ARGUMENTS -> TUPLE ]
create make
feature -- Initialization
  actions: LINKED_LIST[PROCEDURE[ARGUMENTS]]
  make do create actions.make end
feature
  subscribe (an_action: PROCEDURE[ARGUMENTS])
    require action_not_already_subscribed: not actions.h
    do actions.extend (an_action)
    ensure action_subscribed: action.has(an_action) end
  publish (args: G)
    do from actions.start until actions.after
      loop actions.item.call (args) ; actions.forth end
    end
end
```