Design Patterns

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Door/Light Example

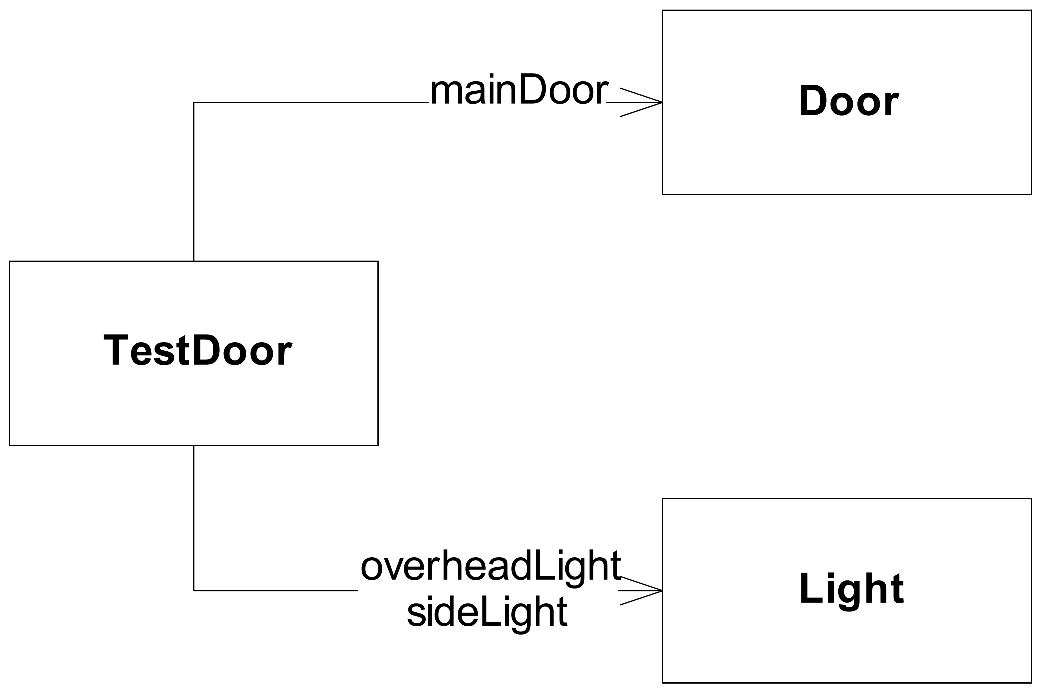
Motivational Example for Observer Pattern

Motivational Example

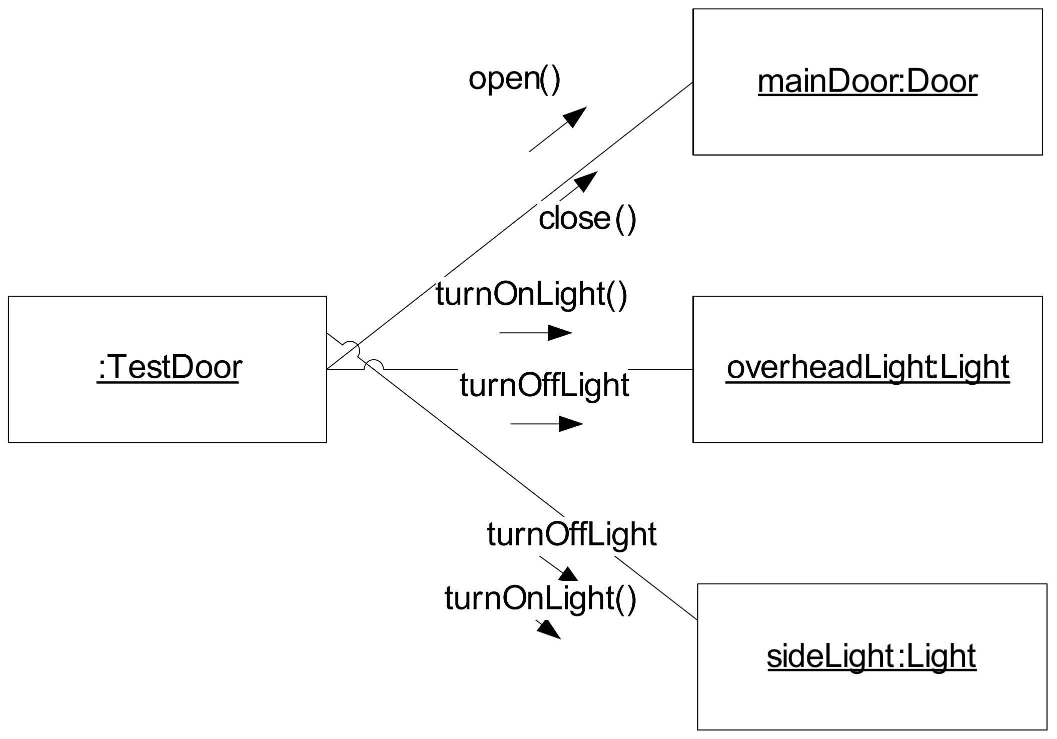
- In an embedded system a Door opening should trigger a Light to turn on
- The Door closing should turn the light off
- Explore the structure of various designs by building a series of test cases
- Six versions:
  - Version 0: No coupling between Door & Light
  - Version 1: Couple Door & Light; Enable door to activate multiple lights
  - Version 2: Introduce Cameras, to be also coupled to Door
  - Version 3: Decouple Light & Camera from Door by refactoring to use Observer Pattern
  - Version 4: Use java.util observer implementation
  - Version 5: Anonymous inner class idiom
  - Version 6: Lambda Idiom

Version 0

- Direct coupling between Door & Light



Class Diagram



Communication Diagram

0:Test

```
public class DoorTest
{
  private Door mainDoor;
  private Light overheadLight;
  private Light sideLight;

  @Before
  public void setUp() throws Exception
  {
    mainDoor = new Door("Main Door");
    overheadLight = new Light("Overhead Light");
    sideLight = new Light("Side Light");
  }

  @After
  public void tearDown() throws Exception
  {
    mainDoor = null;
    overheadLight = null;
    sideLight = null;
  }
```

```
  @Test
  public void testOpenClose()
  {
    mainDoor.open();
    overheadLight.turnOnLight();
    sideLight.turnOnLight();

    assertTrue(overheadLight.getLightState());
    assertTrue(sideLight.getLightState());

    mainDoor.close();
    overheadLight.turnOffLight();
    sideLight.turnOffLight();

    assertFalse(overheadLight.getLightState());
    assertFalse(sideLight.getLightState());
  }
}
```

0:Door

- Door is not aware of Light class

```
public class Door
{
  private String name;
  private boolean isOpen;

  public Door(String name)
  {
    this.name = name;
    isOpen = false;
  }

  public void open()
  {
    if (isOpen == false)
    {
      System.out.println("Opening " + name);
      isOpen = true;
    }
  }

  public void close()
  {

    if (isOpen == true)
    {
      System.out.println("Closing " + name);
      isOpen = false;
    }
  }
}
```

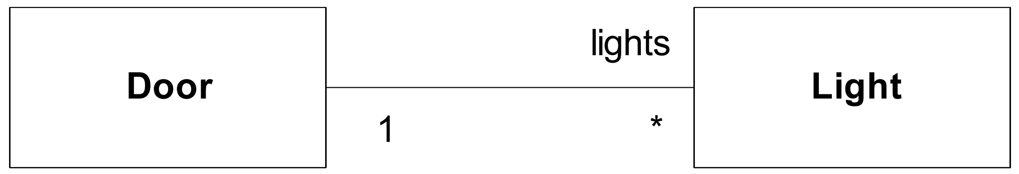
0:Light

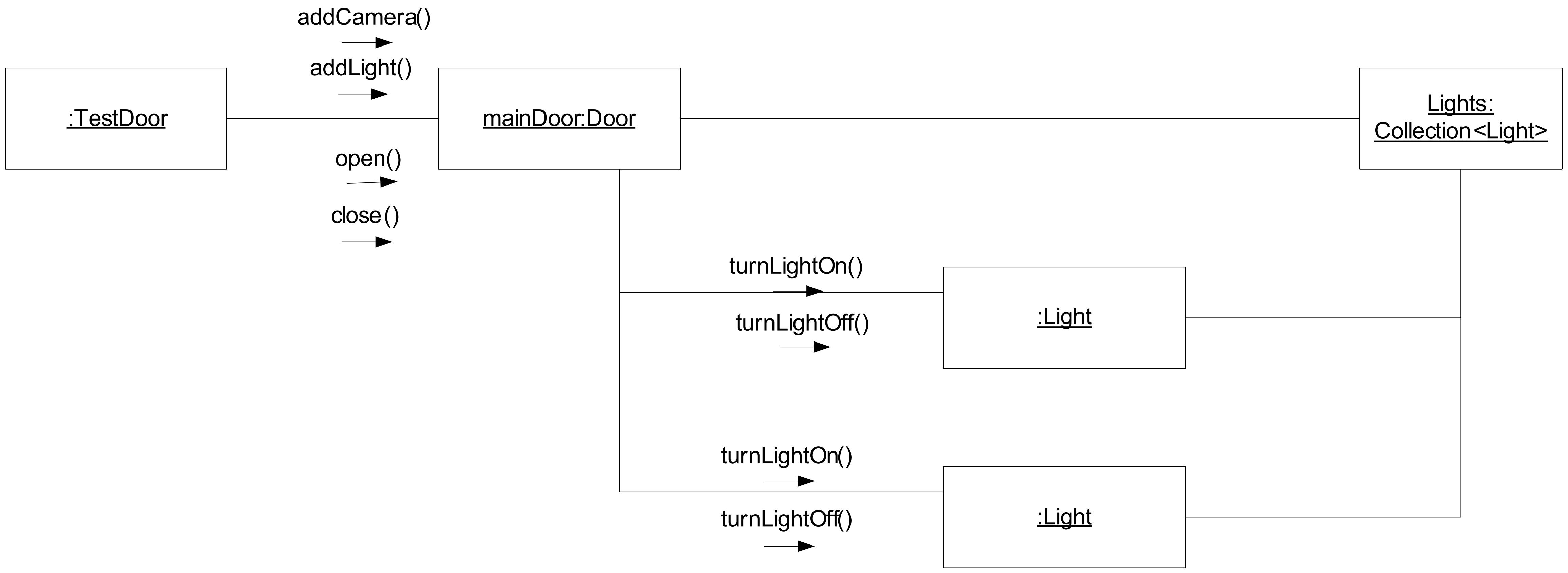
- Light has no dependencies

```java
public class Light
{
  private String name;
  private boolean lightOn;

  public Light(String nm)
  {
    name = nm;
    lightOn = false;
  }

  public void turnOnLight()
  {
    if (!lightOn)
    {
      System.out.println("Turning on light" + name);
      lightOn = true;
      // activate light sensor
    }
  }

  public void turnOffLight()
  {
    if (lightOn)
    {
      System.out.println("Turning Off light" + name);
      lightOn = false;
      // deactivate light sensor
    }
  }

  public boolean getLightState()
  {
    return lightOn;
  }
}
```

Version 1

- Couple Door & Light; Enable door to control multiple lights





1:TestDoor

```
public class DoorTest
{
  private Door mainDoor;
  private Light overheadLight;
  private Light sideLight;

  @Before
  public void setUp() throws Exception
  {
    mainDoor = new Door("Main Door");
    overheadLight = new Light("Overhead Light");
    sideLight = new Light("Side Light");
  }

  @After
  public void tearDown() throws Exception
  {
    mainDoor = null;
    overheadLight = null;
    sideLight = null;
  }
```

```
  @Test
  public void testOpenClose()
  {
    mainDoor.addLight(overheadLight);
    mainDoor.addLight(sideLight);

    mainDoor.open();
    assertTrue(overheadLight.getLightState());
    assertTrue(sideLight.getLightState());

    mainDoor.close();
    assertFalse(overheadLight.getLightState());
    assertFalse(sideLight.getLightState());

    mainDoor.open();
    assertTrue(overheadLight.getLightState());
    assertTrue(sideLight.getLightState());
  }
```

1:TestDoor - using JMock

- Use the JMock libraries to verify that open/closing the door triggers an on/off call to the light object.

```
public class DoorTest
{
  private Door mainDoor;
  private Mockery context;

  @Before
  public void setUp() throws Exception
  {
    mainDoor = new Door("Main Door");
    context = new Mockery() {{
        setImposteriser(ClassImposteriser.INSTANCE);
    }};
  }

  @Test
  public void testOpenCloseMock()
  {
    final Light light = context.mock(Light.class);

    mainDoor.addLight(light);
    context.checking(new Expectations() {{
                        one(light).turnOnLight();
                      }});
    mainDoor.open();
    context.assertIsSatisfied();
    context.checking(new Expectations() {{
                        one(light).turnOffLight();
                      }});
    mainDoor.close();
    context.assertIsSatisfied();
  }
```

1:Door

```
public class Door
{
  private String name;
  private boolean isOpen;
  private Collection<Light> lights;

  public Door(String name)
  {
    this.name = name;
    isOpen = false;
    lights = new HashSet<Light>();
  }

  public void open()
  {
    if (isOpen == false)
    {
      System.out.println("Opening " + name);
      isOpen = true;
      turnOnLights();
    }
  }

  public void close()
  {

    if (isOpen == true)
    {
      System.out.println("Closing " + name);
      isOpen = false;
      turnOffLights();
    }
  }
```

```
  public void addLight(Light light)
  {
    lights.add(light);
  }

  private void turnOnLights()
  {
    for (Light light : lights)
    {
      light.turnOnLight();
    }
  }

  private void turnOffLights()
  {
    for (Light light : lights)
    {
      light.turnOffLight();
    }
  }
}
```

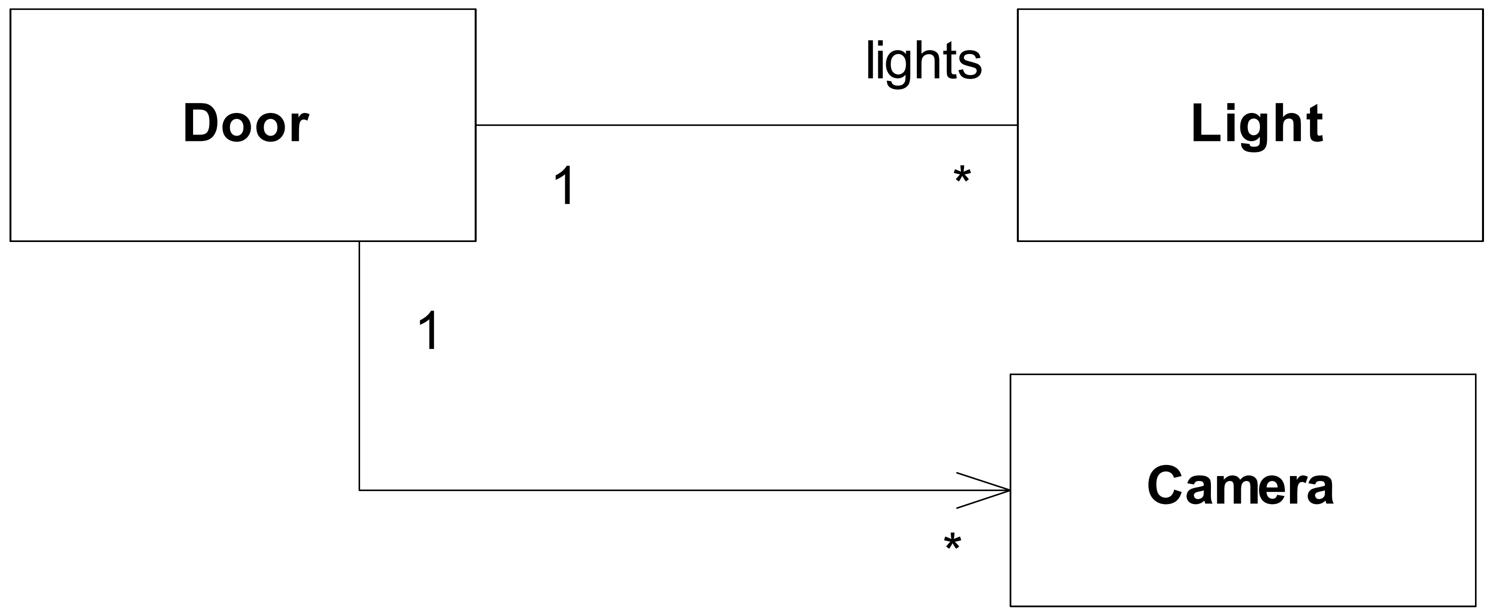
1:Light

- No change from previous version

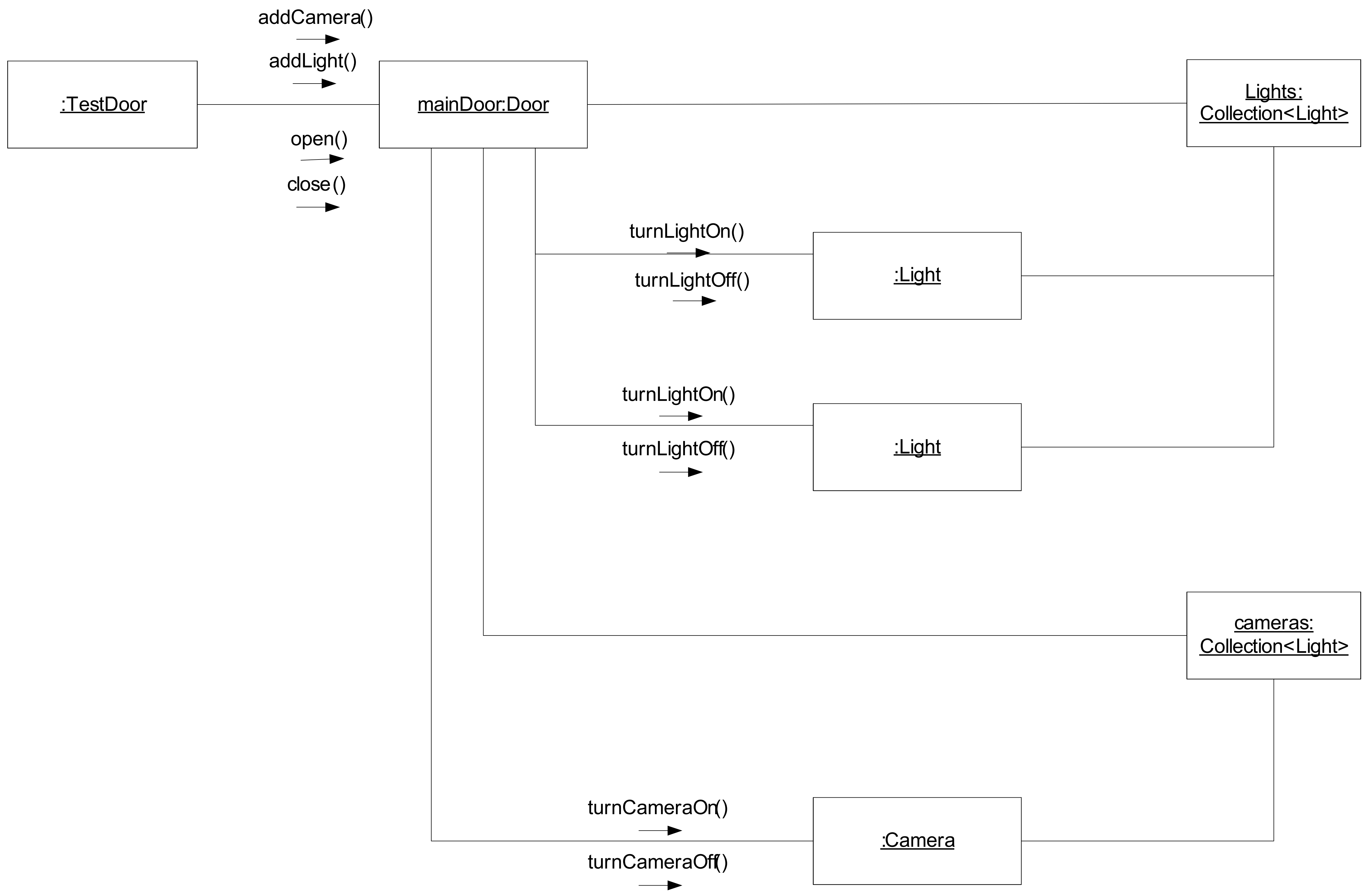
```
public class Light
{
  private String name;
  private boolean lightOn;

  public Light(String nm)
  {
    name = nm;
    lightOn = false;
  }

  public void turnOnLight()
  {
    if (!lightOn)
    {
      System.out.println("Turning on light" + name);
      lightOn = true;
      // activate light sensor
    }
  }

  public void turnOffLight()
  {
    if (lightOn)
    {
      System.out.println("Turning Off light" + name);
      lightOn = false;
      // deactivate light sensor
    }
  }

  public boolean getLightState()
  {
    return lightOn;
  }
}
```

Version 2: Introduce Camera

- Introduce Cameras, to be also coupled to Door



2: Communication Diagram



2:TestDoor

```
public class DoorTest
{
  private Door mainDoor;
  private Light light;
  private Camera camera;
  private Mockery context;

  @Before
  public void setUp() throws Exception
  {
    context = new Mockery() {{
        setImposteriser(ClassImposteriser.INSTANCE);
    }};
    light = context.mock(Light.class);
    camera = context.mock(Camera.class);

    mainDoor = new Door("Main Door");
    mainDoor.addLight(light);
    mainDoor.addCamera(camera);
  }

  @After
  public void tearDown() throws Exception
  {
    mainDoor = null;
  }
```

```
  @Test
  public void testOpenCloseMock()
  {
    context.checking(new Expectations() {{
                    one(light).turnOnLight();
                    one(camera).turnOnCamera();
                  }});

    mainDoor.open();
    context.assertIsSatisfied();

    context.checking(new Expectations() {{
                    one(light).turnOffLight();
                    one(camera).turnOffCamera();
                  }});
    mainDoor.close();
    context.assertIsSatisfied();
  }
}
```

2:Door

```
public class Door
{
  private String name;
  private boolean isOpen;
  private Collection<Light> lights;
  Collection<Camera> cameras;

  public Door(String name)
  {
    this.name = name;
    isOpen = false;
    lights = new HashSet<Light>();
    cameras = new HashSet<Camera>();
  }

...
  public void addCamera(Camera camera)
  {
    cameras.add(camera);
  }

  public void open()
  {
    if (isOpen == false)
    {
      System.out.println("Opening " + name);
      isOpen = true;
      turnOnLights();
      turnOnCameras();
    }
  }

...
```

```
...

  private void turnOnCameras()
  {
    for (Camera camera : cameras)
    {
      camera.turnOnCamera();
    }
  }

  private void turnOffCameras()
  {

    for (Camera camera : cameras)
    {
      camera.turnOffCamera();
    }
  }
}
```

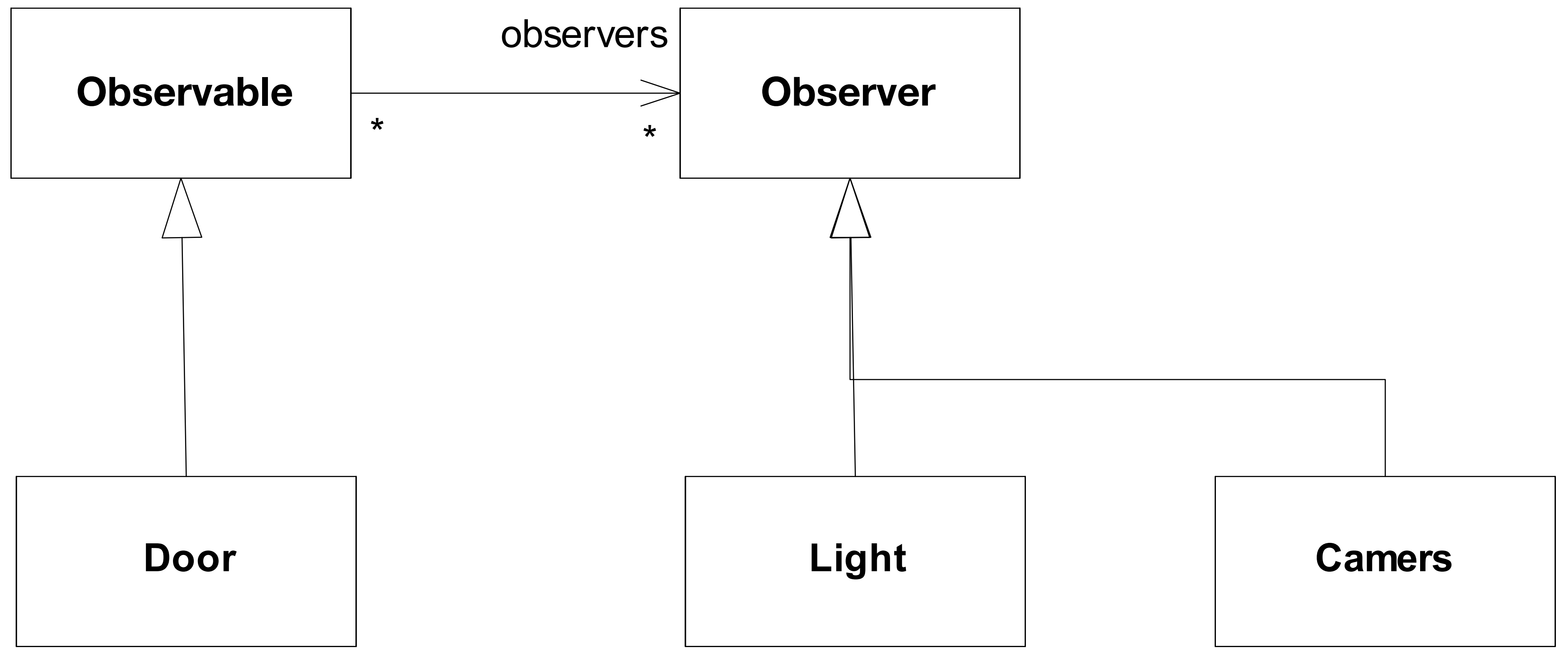
3:Light

- No change from previous versions

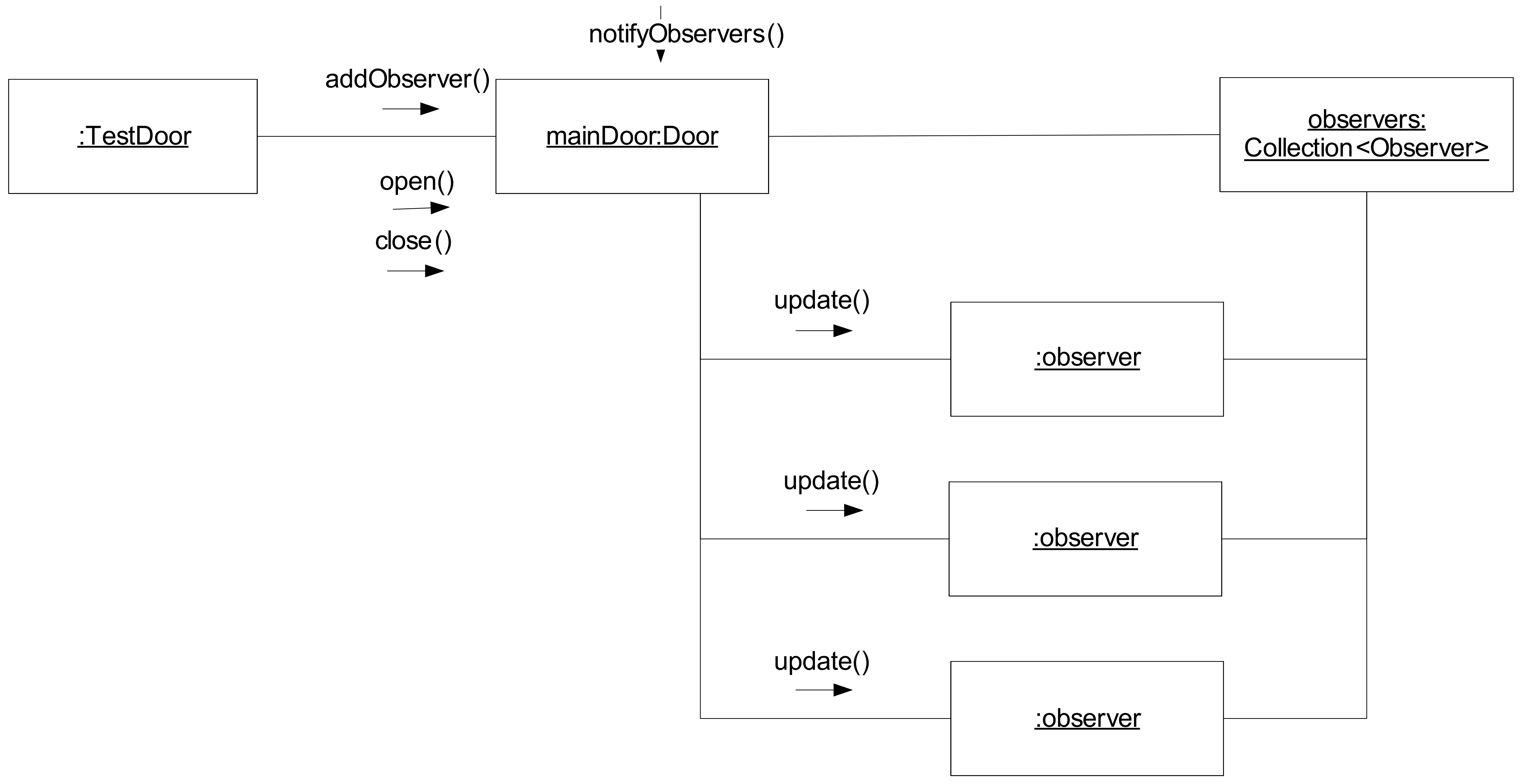
```
public class Light
{
  private String name;
  private boolean lightOn;

  public Light(String nm)
  {
    name = nm;
    lightOn = false;
  }

  public void turnOnLight()
  {
    if (!lightOn)
    {
      System.out.println("Turning on light" + name);
      lightOn = true;
      // activate light sensor
    }
  }

  public void turnOffLight()
  {
    if (lightOn)
    {
      System.out.println("Turning Off light" + name);
      lightOn = false;
      // deactivate light sensor
    }
  }

  public boolean getLightState()
  {
    return lightOn;
  }
}
```

Version 3: Observer

- Decouple Light & Camera from Door by refactoring to use Observer Pattern



3: Communication Diagram



3:TestDoor

```
public class DoorTest
{
  private Door mainDoor;
  private Light light;
  private Camera camera;
  ...

  @Before
  public void setUp() throws Exception
  {
    ...

    mainDoor = new Door("Main Door");
    mainDoor.addObserver(light);
    mainDoor.addObserver(camera);
  }
```

```
  @Test
  public void testOpenCloseMock()
  {
    context.checking(new Expectations() {{
                        one(light).update(mainDoor, true);
                        one(camera).update(mainDoor, true);
                      }});
    mainDoor.open();
    context.assertIsSatisfied();
    context.checking(new Expectations() {{
                        one(light).update(mainDoor, false);
                        one(camera).update(mainDoor, false);
                      }});
    mainDoor.close();
    context.assertIsSatisfied();
  }
}
```

3:Observer & Observable

```
public interface Observer
{
  public void update(Observable ob, Object o);
}
```

```
public class Observable
{
  protected Collection<Observer> observers;

  public Observable()
  {
       observers = new HashSet<Observer>();
  }

  public void addObserver(Observer light)
  {
    observers.add(light);
  }

  public void notifyObservers(Object o)
  {
    for (Observer observer : observers)
    {
      observer.update(this, o);
    }
  }
}
```

3:Door

- Door is significantly simplified.
- All dependency management is handled in the Observable base class.

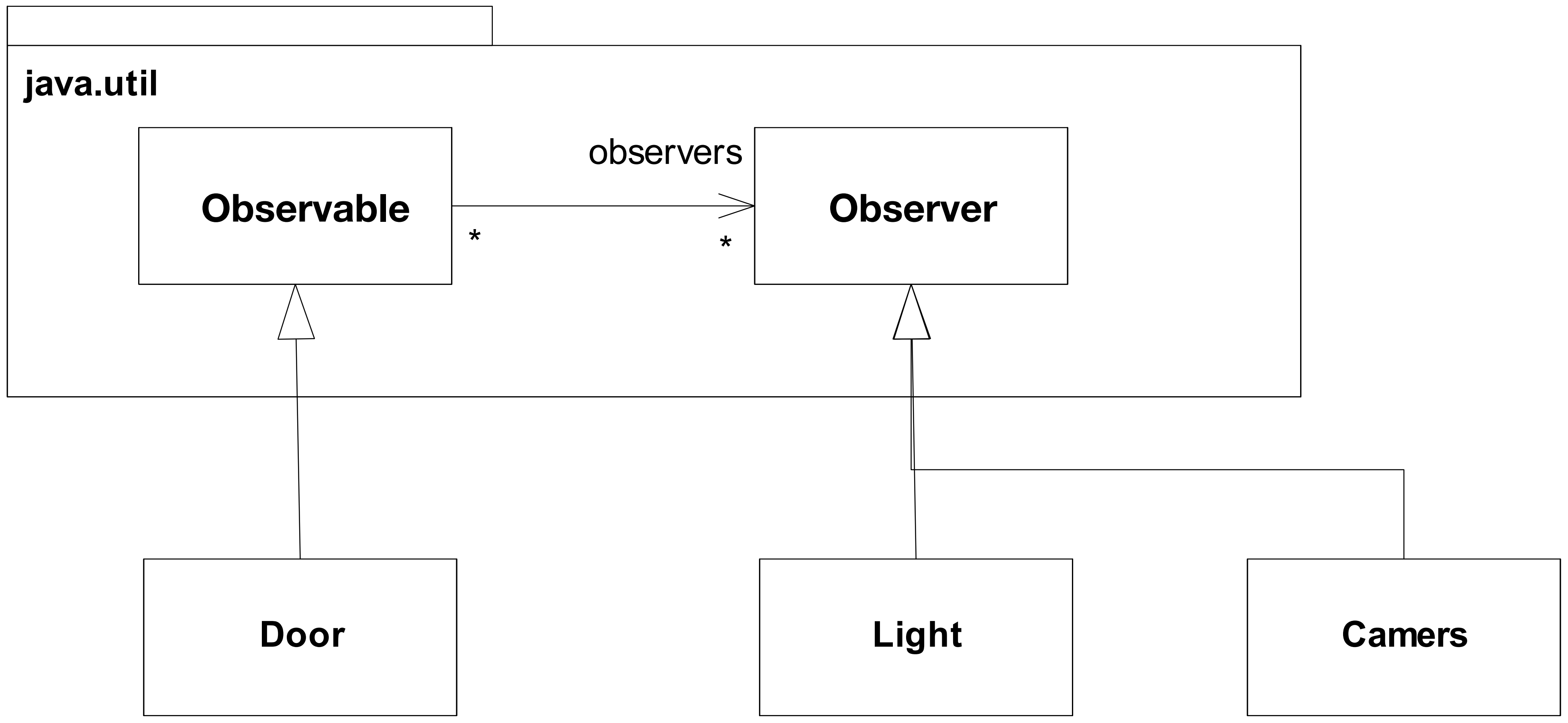
```
public class Door extends Observable
{
  private String name;
  private boolean isOpen;

  public Door(String name)
  {
    this.name = name;
    isOpen = false;
  }

  public void open()
  {
    if (isOpen == false)
    {
      System.out.println("Opening " + name);
      isOpen = true;
      notifyObservers(isOpen);
    }
  }

  public void close()
  {
    if (isOpen == true)
    {
      System.out.println("Closing " + name);
      isOpen = false;
      notifyObservers(isOpen);
    }
  }
}
```

3:Camera (Light similar)

```
public class Camera implements Observer
{
  private String name;
  private boolean cameraOn;

  public Camera(String nm)
  {
    name = nm;
    cameraOn = false;
  }

  public void update(Observable ob, Object o)
  {
    Boolean doorStatus = (Boolean) o;

    if (doorStatus == true)
    {
      turnOnCamera();
    }
    else
    {
      turnOffCamera();
    }
  }

  public boolean getCameraState()
  {
    return cameraOn;
  }
}
```

```
  public void turnOnCamera()
  {
    if (!cameraOn)
    {
      System.out.println("Turning on camera " + name);
      cameraOn = true;
      // activate light sensor
    }
  }

  public void turnOffCamera()
  {

    if (cameraOn)
    {
      System.out.println("Turning Off camera " + name);
      cameraOn = false;
      // deactivate light sensor
    }
  }
```

4:Java.util Observer Implementation



4:Door, Light & Camera

```
public class Door extends Observable
{
...
}
```

```
public class Light implements Observer
{
...
}
```

```
public class Camera implements Observer
{
...
}
```

5: Anonymous Inner Class Idiom

- With Observe implementations in Java, it is common to implement the observer inline.
- This is called an "Anonymous Inner Class".
- In the example here, a new Observer implementation is being created, and the single required method provided, all within the parameter list to the addObserver() method.
- Can be difficult to read - but extremely common, particularly in GUI code.

```
@Test
public void demonstrateAnonymousInnerClass()
{
  mainDoor.addObserver(new Observer()
    {
      public void update(Observable obs, Object o)
      {
        Boolean open = (Boolean) o;

        if (open == true)
        {
          System.out.println("main Door opening");
        }
        else
        {
          System.out.println("main Door closing");
        }
      }
    });
}
```

6: Lambda Idiom

- More elegant replacement for Anonymous inner class

```
@Test
public void demonstrateLambda()
{
  Observer observer = (Observable obs, Object o) ->
  {
    Boolean open = (Boolean) o;
    if (open == true)
    {
      System.out.println("main Door opening");
    }
    else
    {
      System.out.println("main Door closing");
    }
  };

  mainDoor.addObserver(observer);
  mainDoor.open();
}
```