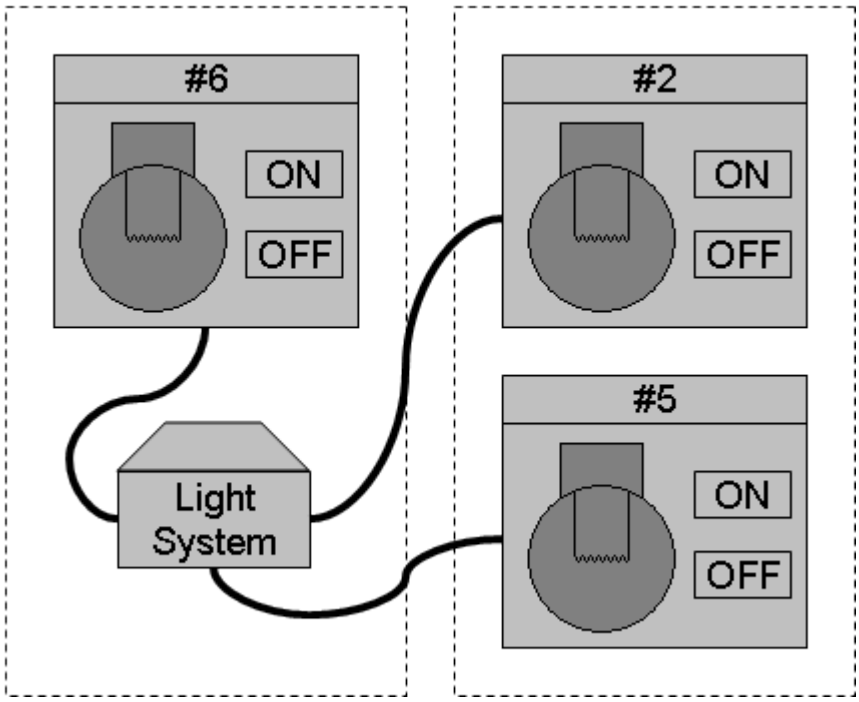
CS 332 Norman

Lab: A Festival of Lights

Some Light Reading

This lab will feature a hypothetical system, in which various light panels are connected to a light system. Each panel features a light bulb. When any panel's "on" button is pressed, all the lights turn on. Likewise, each "off" button turns off all the lights.



Alice's Computer *Bob's Computer*

We will simulate such a system by creating instances of the Java classes `LightSystem` and `LightPanel`. These instances may reside on different computers, as pictured above.

Go ahead and download all the files from `/home/cs/332/fa2019/lab1/` to a new directory under your home directory.

For the most part, all we'll do with the `LightSystem` class itself is make new instances of it. Here is a summary of what is in the class.

LightSystem Class

```
DEFAULT_PORT

LightSystem()
LightSystem(int port)
static Random getRandom()
```

The `LightPanel` class allows you to check if the light is on, and turn the light on or off. In addition, each `LightPanel` has an ID (an integer from 1 to 15). Here is a summary of the LightPanel class.

LightPanel Class

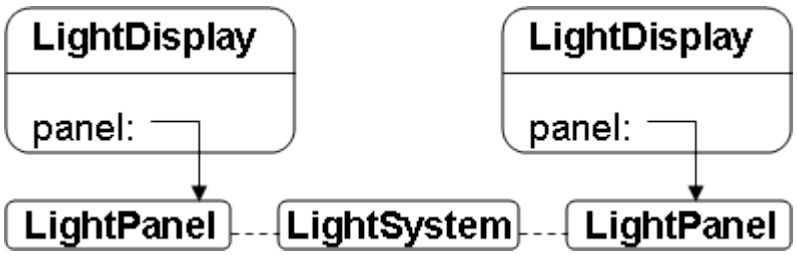
```
LightPanel()
LightPanel(String host, int port)
int getID()
boolean isOn()
void switchOn()
void switchOff()
String toString()
```

Although a `LightPanel` may conjure up a visual image in your mind, you may create and use `LightPanel`'s without ever seeing one appear on the screen. If you would like to see a `LightPanel`, you must create an instance of the `LightDisplay` class, and pass it the `LightPanel` you wish to view. Here is summary of the LightDisplay class.

LightDisplay Class

```
LightDisplay(LightPanel panel)
```

Each `LightDisplay` keeps track of a particular `LightPanel`, as shown in the following instance diagram.



Time to Light the Lights

Create a new `Test` class in a file called **`Test.java`**, and program it to run the following code.

```
LightSystem system = new LightSystem();
LightDisplay d1 = new LightDisplay(new LightPanel());
LightDisplay d2 = new LightDisplay(new LightPanel());
```

Try turning on and off the lights.

Now, go through the following files and add **good** documentation to them. You need to add Javadoc comments above each class definition and method definition. You'll want to add comments to any code in the classes that isn't completely obvious.

```
LightDisplay.java
LightSystem.java
LightPanel.java
```

A Photonic Relationship

Find a partner (or several partners), and run a `LightSystem` (with a `LightPanel` or two) on one of your computers. Look up the IP address of that computer.

Do not run a `LightSystem` on the other computer. Instead, create and display a couple of `LightPanel`s, passing the IP address and `LightSystem.DEFAULT_PORT` to the `LightPanel` constructor. If you are successful, you should each be able to turn on/off all the lights.

In a Bit

We wish to communicate binary data by turning on/off the lights. A `LightPanel` by itself won't let us broadcast and receive bits – all we are doing is turning on the voltage on this shared wire, which makes the lights come on. To send bits, we'll now create a new class called `BitHandler`. Each `BitHandler` will have a reference to its own `LightPanel` in an instance variable, and will use it to allow us to perform higher-level tasks. The BitHandler will be able to send bits on the wire using Manchester Encoding, as (briefly) discussed in class (section 6.16 of the text).

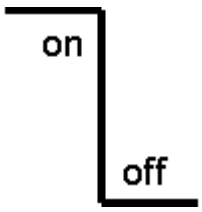
`BitHandler`'s constructor should take no arguments, and should initialize its internal `LightPanel` to point to a new instance of the `LightPanel` class. (It would also be a good idea to create a second constructor and have it use an IP address and port to initialize the `LightPanel`.)

Since we'll rely on timing to distinguish one bit from another, it will be helpful to define the following method, which allows us to pause for a given number of milliseconds.

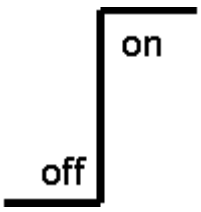
```
public static void pause(int milliseconds)
{
     try {
          Thread.sleep(milliseconds);
     } catch(InterruptedException e) {
          // should never get here, but
          // let's print something just in case
          e.printStackTrace();
     }
}
```

Our `BitHandler` class should also keep track of a *half delay*—a number of milliseconds corresponding to half the time required to broadcast a single bit. We'll initialize this value to be 500 milliseconds. Later in the lab, we'll see if we can lower this value and still communicate reliably.

We'll represent the binary values "0" and "1" by setting the light as follows over a *full delay* period (two half delays).



Binary "0"



Binary "1"

Write the methods `broadcastZero` and `broadcastOne`, which should use the `LightPanel` to turn the light on/off as depicted above. Now modify your `Test` class to create a `BitHandler` and have it broadcast the sequence "100". Draw a diagram to determine how long the light should be on/off, and test that the light's behavior matches your prediction.

A Burst of Bits

Next add a method called `broadcast` to your `BitHandler` class, which should take in a `String bits` consisting only of the characters "0" and "1", and should use your `broadcastZero` and `broadcastOne` methods to broadcast this sequence of digits. Once the final digits have been broadcast, be sure to switch the light off. When you've finished, test that your `broadcast` method works correctly.

Seeing Things

The `LightPanel`'s `toString` method tells us its ID #. Create a `BitHandler` `toString` method to call the `LightPanel`'s `toString` method and return that value.

Now look at `BitDisplay.java`—a simple GUI for showing and controlling your `BitHandler`.

Update your Test so that you create a new `BitDisplay` and use it to broadcast bits through your `BitHandler`.

Now, go through all the `Bit*.java` files and add good Javadoc documentation to these, as you did before with the `Light*.java` files.

Light Pollution

Next we would like to detect collisions—when two `BitHandlers` are broadcasting at the same time. Whenever a collision has been detected, we'll throw a `CollisionException`. Go ahead and define the very simple `CollisionException` class as follows, in CollisionException.java.

```
public class CollisionException extends Exception
{
}
```

Now modify your `BitHandler` class methods `broadcastZero()` and `broadcastOne()` so that they test if anyone has changed the light after each pause, and throw a `CollisionException` at such times.

You will now get an error message when you attempt to compile. Unlike `NullPointerException`, `ClassCastException`, and `ArrayIndexOutOfBoundsException`, our `CollisionException` class is not a runtime exception (does not extend the `RuntimeException` class). We will therefore need to handle it at compile time, by declaring or catching it. Go ahead and declare that your `broadcastZero` and `broadcastOne` methods throw a `CollisionException`. When you compile now, you will discover that you need to declare that `broadcast` also throws this exception.

Compiling once more will reveal that the `BitDisplay` class now needs to handle this exception. Add code to catch the exception and indicate that there was a collision by setting the `receiveField`'s text to "Collision!"

Now test that you can broadcast a string of bits without the display reporting a collision. Then try broadcasting two strings at once, and test that the display correctly identifies the collision.

Now, go through the files again and make sure everything is documented **well**. All the Javadoc explanations should be up-to-date, etc.

Revenge of the Finite State Machines

There is code in `BitHandler`'s `run`() method that repeatedly checks the "wire" to see if the light has changed on or off, etc., and then interprets the results into bits. As it examines the light, our handler may find itself in one of the following states.

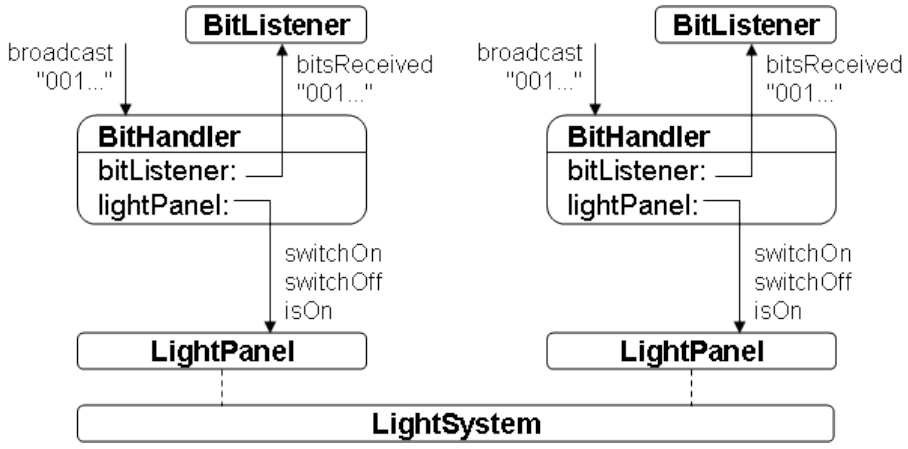
State Name	Light Status	Description
`SILENT`	off	No bits are being broadcast.
`EXPECT_ZERO`	on	We expect that we're about to read a "0".
`EXPECT_ONE`	off	We expect that we're about to read a "1"
`HALF_ZERO`	off	We've seen the first half of a "0", and we're waiting for the second half.
`HALF_ONE`	on	We've seen the first half of a "1", and we're waiting for the second half.
`GARBAGE`	on	The light has been on for too long.

There are three situations that will cause the handler to change to a new state:

- The light just changed after a half delay.
- The light just changed after a full delay.
- The light has not changed for a timeout period of 3 half delays.

The code in `run()` implements the finite state machine, but does not call `notifyReceived()`. All you have to do is uncomment those lines to get it to work. Make that change now.

Here is a picture of the relationship between classes that now exists.



Change your `Test` class to create a `LightSystem`, a `ListDisplay` (which takes a `LightPanel` as an argument) and a `BitDisplay` (which takes a `BitHandler` as an argument). Have a partner do the same (except the partner does not start up a `LightSystem`, but shares yours). Test that you can broadcast bits from one handler to the other. **NOTE NOTE NOTE: In order for this to work, all bit strings sent over the wire must start with a "0" bit.**

The Speed of Light

Now test how low you can set the `BitHandler`'s half delay value without sacrificing reliability. All machines using one `LightSystem` must have the same half delay for this to work.

Submit Your Code

You need to submit your files to `/home/cs/332/current/<yourid>/lab1/`. Many of these files have only had documentation added to them. Submit **two** `Test` files – `TestServer.java` and `TestClient.java`. `TestServer.java` contains code to start up a `LightSystem` and a `LightDisplay` and `BitDisplay`. `TestClient.java` does not start up a `LightSystem`, but instead connects to a `LightSystem` on another machine (you may leave the IP address in your code that you used when you tested the code), and then starts up a `BitDisplay` as well.

Also, submit a `README.txt` file that tells me which other pair of students tested against, so that I can see if your code and that team's code works together – i.e., because they use the same value for the half delay.

Grading Rubric:

20 pts total

- 15 points for correctness
- 5 points for thorough and correct documentation