Inf1B

Object Design

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adapting earlier versions by Perdita Stevens, Ewan Klein, Volker Seeker, et al.

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Basic Object Design Principles

Cohesion describes how well a unit of code maps to a logical task or entity. *A good OO design aims for high cohesion.*

Coupling describes the interconnectedness of classes. *A good OO design aims for loose coupling.*

Cohesion Example

```
public static final int FOX_WIN_ROW = 0;

public static boolean isFoxWin(String foxPos) {
  // error handling code omitted ...

  String rowCoord = boardCoords.substring(1);
  int foxRow = Integer.parseInt(rowCoord) - 1;

  boolean isWin = foxRow == FOX_WIN_ROW;
  return isWin;
}
```

In this code, the method does two things at the same time.
What if the coordinate format would change?

Cohesion Example

```
private static final int FOX_WIN_ROW = 0;

private static int getRowCoord(String boardCoords) {
  String rowCoord = boardCoords.substring(1);
  int row = Integer.parseInt(rowCoord) - 1;
  return row;
}

public static boolean isFoxWin(String foxPos) {
  // error handling code omitted ...

  int foxRow = getRowCoord(foxPos);

  boolean isWin = foxRow == FOX_WIN_ROW;
  return isWin;
}
```

This code is now more cohesive and coordinate format changes would only have to be addressed in one place.

Cohesion Example

Code duplication can be a sign of poor cohesion.

Demo

Coupling Example

```
public static boolean isFoxWin(String foxPos) {
  if (!isBoardCoordinate(pos)) {
      throw new IllegalArgumentException("Given position must"
      + " be a valid board coordinate but is: " + pos);
  }

  int foxRow = getRowCoord(foxPos);

  boolean isWin = foxRow == FOX_WIN_ROW;
  return isWin;
}
```

Responsibility Driven Design and **Encapsulation** help to loosen coupling within code.

Coupling Example

```
public static boolean isFoxWin(BoardCoordinate foxPos) {
  Objects.requireNonNull(foxPos, " ... ");

  boolean isWin = foxPos.getRow() == FOX_WIN_ROW;
  return isWin;
}
```

The `BoardCoordinate` class guarantees valid data and takes responsibility for coordinate translation. Also, it can be changed internally without affecting the game logic.

Coupling Example

```
public class BoardCoordinate {
    private final int row;
    private final int column;

    public BoardCoordinate(int row, int column) {
        if (row < 0 || column < 0) {
            throw new IllegalArgumentException("Invalid ...");
        }
        this.row = row;
        this.column = column;
    }

    public int getRow() { return row; }
    public int getColumn() { return column; }

    @Override
    public String toString() {
        String rowRepr = "" + (row + 1);
        String columnRepr = "" + (char)('A' + column);
        return columnRepr + rowRepr;
    }
}
```

Enums

Enumerated Types

A type whose legal values consist of a fixed set of constants.

For example, types of figures in a game:

```
public static final String HOUND_FIELD = "H";
public static final String FOX_FIELD = "F";
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or fruit ...

```
public static final int APPLE_FUJI = 0;
public static final int APPLE_PIPPIN = 1;
public static final int APPLE_GRANNY_SITH = 2;

public static final int ORANGE_NAVEL = 0;
public static final int ORANGE_TEMPLE = 1;
public static final int ORANGE_BLOOD = 2;
```

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```

Those are know as *int enum pattern* or *String enum pattern*.

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This type of pattern has many shortcomings:

- no type safety

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- little expressive power

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- no type safety
- little expressive power
- no distinct name spaces
- no easy way to iterate over all items
- no easy way to translate into int enum constants printable strings
- string enum constants can cause performance problems due to string comparisson

Enums

Luckily, Java offers a way to overcome all of those with the **enum type**:

```
public enum Figure  FOX, HOUND
public enum Apple  FUJI, PIPPIN, GRANNY_SMITH
public enum Orange  NAVEL, TEMPLE, BLOOD
```

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public enum Figure  FOX, HOUND
public enum Apple  FUJI, PIPPIN, GRANNY_SMITH
public enum Orange  NAVEL, TEMPLE, BLOOD
```

In Java, enums are full-fledged classes that export one instance for each enumeration constant via a public static final field.

Enums are type safe

```
private static Figure swapPlayers(Figure currentTurn) {
  if (currentTurn == Figure.FOX) {
      return Figure.HOUND;
  } else {
      return Figure.FOX;
  }
}
```

All of the following would cause a compiler error.

```
Figure nextToMove = swapPlayers(Orange.TEMPLE);
Figure nextToMove = swapPlayers(Figure.CAT);
Figure nextToMove = swapPlayers(0);
```

Enums are efficient

```
private static Figure swapPlayers(Figure currentTurn) {
  if (currentTurn == Figure.FOX) {
      return Figure.HOUND;
  } else {
      return Figure.FOX;
  }
}
```

Comparison is fast because only references need to be compared.

Enums can be iterated

```
for (Apple apple : Apple.values()) {
  // do what you want
}
```

Each enum class automatically comes with a **values** method which returns a collection of all available enum instances.

Enums can be printed

```
for (Apple apple : Apple.values()) {
    System.out.println(apple.name());
    // or just use toString()
}
```

Output

```
FUJI
PIPPIN
GRANNY_SMITH
```

Each enum class provides a named string for all of its instances.

Enums can be parsed

```
String userInput = "BLOOD";
Orange myFruit = Orange.valueOf(userInput);
```

The **valueOf** method allows parsing string values to corresponding enum types. But beware, illegal strings will cause an exception.

Advanced Enum Programming

Since enums are full-fleged classes, much more is possible than mentioned above:

- specify methods
- associate data with each constant
- ...

Comparing Objects

Java rules for comparrisson

For Primitives use ==

For Object References use ==

For Object States use `equals` (if it is implemented)

Custom Types in HashMaps

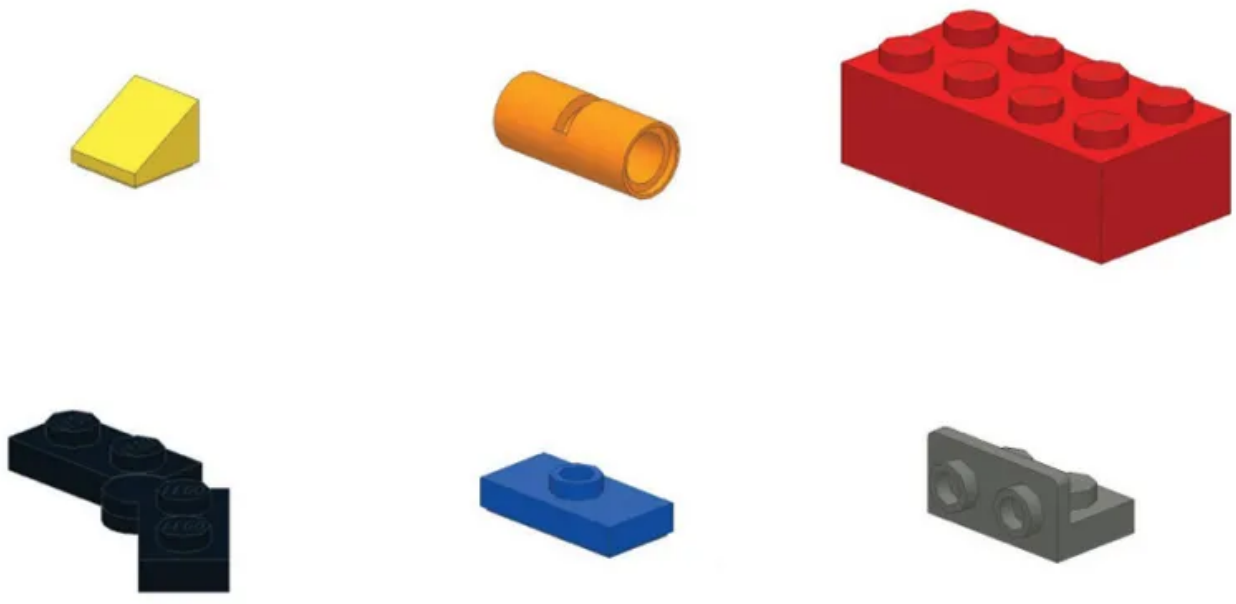
You can also put your own data types into a `HashMap`:

```
HashMap<String, Circle> data = new HashMap<String, Circle>();
data.put("Small", new Circle(2));
data.put("Large", new Circle(200));
```

Using custom types as keys, is more tricky: You will have to make sure they have an `equals` method and produce the same hash code.

Design Patterns

Towards Software Engineering



First learn your basic tools and material.

Source: https://i.kinja-img.com/gawker-media/image/upload/s–Zo3E8URT–/c_scale,f_auto,fl_progressive,q_80,w_800/18muwoa3oozw6jpg.jpg

Towards Software Engineering

First learn your basic tools and material.

Then build large houses ...

Source: http://hannesdorfmann.com/images/legohouse/legohouse.jpg

Towards Software Engineering

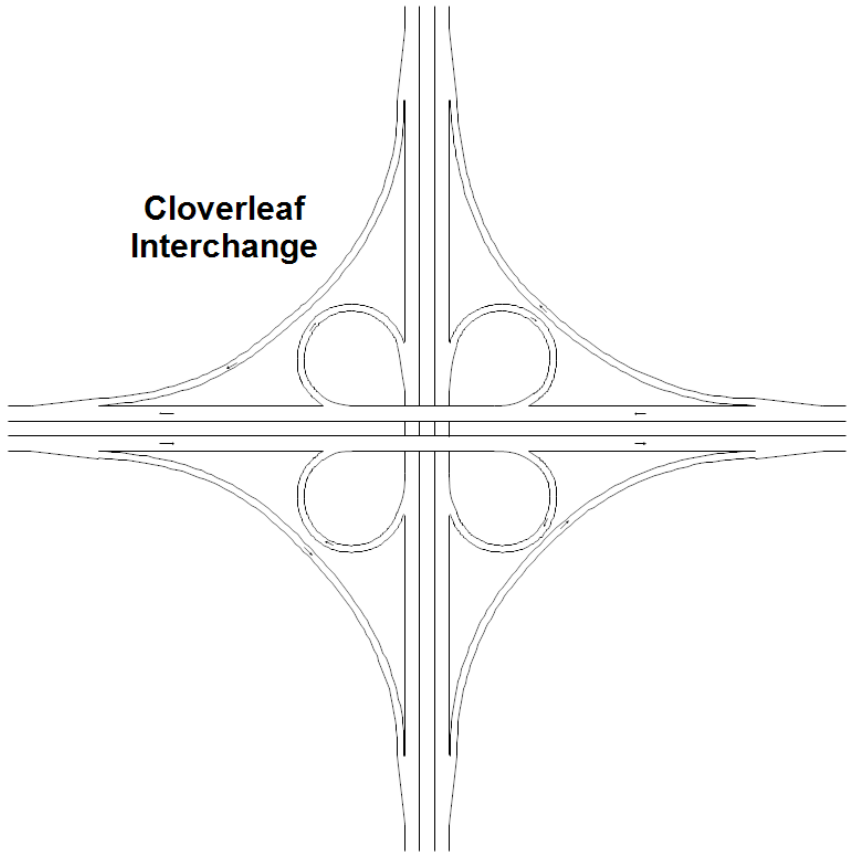
First learn your basic tools and material.

Then build large houses ...or even cities.

Source: https://i.kinja-img.com/gawker-media/image/upload/s–uTscbBDV–/c_scale,f_auto,fl_progressive,q_80,w_800/tu3yxy86lxwmw5vw8yeu.jpg

Design Patterns

Software Design Patterns are blueprints of solutions for common software design problems.



Source: https://www.rff.com/cloverleaf.png

Classification

- Creational Patterns
- Structural Patterns
- Behavioural Patterns

Creational Example: Singleton

Problem

- access a resource in your program

Creational Example: Singleton

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- access a resource in your program $\rightarrow$ **database resource**

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- multiple classes need access

Creational Example: Singleton

Problem

- access a resource in your program $\rightarrow$ **database resource**
- initialising resource access is expensive $\rightarrow$ **only one instance**
- multiple classes need access $\rightarrow$ **globally available**

Creational Example: Singleton Solution?

```
public class Database {
    private final DBConnection connection;

    public Database() {
        connection = new DBConnection("myuser",
                                      "myhost", "mydatabase");
        connection.connect();
    }

    public List<String> query(String q) { ...
}
```

Creational Example: Singleton Solution?

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public class Database {
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        connection = new DBConnection("myuser",
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    }

    public List<String> query(String q) { ...
}
```

Globally available instance not guaranteed!

Creational Example: Singleton Solution!

```
public class Database {
    private static Database dbase;
    private final DBConnection connection;

    public Database() {
        connection = new DBConnection("myuser",
                                      "myhost", "mydatabase");
        connection.connect();
    }

    public List<String> query(String q) { ...
}
```

Add private static field for storing the singleton instance.

Creational Example: Singleton Solution!

```
public class Database {
    private static Database dbase;
    private final DBConnection connection;

    public Database() {
        connection = new DBConnection("myuser",
                                      "myhost", "mydatabase");
        connection.connect();
    }

    public static Database getInstance() {
        // ?
    }

    public List<String> query(String q) { ...
}
```

Declare public static creation method to access the singleton instance.

Creational Example: Singleton Solution!

```
public class Database {
    private static Database dbase;
    private final DBConnection connection;

    public Database() {
        connection = new DBConnection("myuser",
                                      "myhost", "mydatabase");
        connection.connect();
    }

    public static Database getInstance() {
        if(dbase == null) dbase = new Database();
        return dbase;
    }

    public List<String> query(String q) { ...
}
```

Lazily create the instance of the singleton if necessary and return it.

Creational Example: Singleton Solution!

```
public class Database {
    private static Database dbase;
    private final DBConnection connection;

    private Database() {
        connection = new DBConnection("myuser",
                                      "myhost", "mydatabase");
        connection.connect();
    }

    public static Database getInstance() {
        if(dbase == null) dbase = new Database();
        return dbase;
    }

    public List<String> query(String q) { ...
}
```

Make the singleton constructor private.

Creational Example: Singleton Solution!

```
public static void main(String[] args) {
    Database db = Database.getInstance();
    db.query(args[0]);
}
```

In a client, use the getInstance method to access the singleton.

Structural Example: Facade

Problem

- you need to integrate a complex library into your own codebase
- many interdependencies between your own code and the third party code

Structural Example: Facade

Problem

- you need to integrate a complex library into your own codebase
- many interdependencies between your own code and the third party code

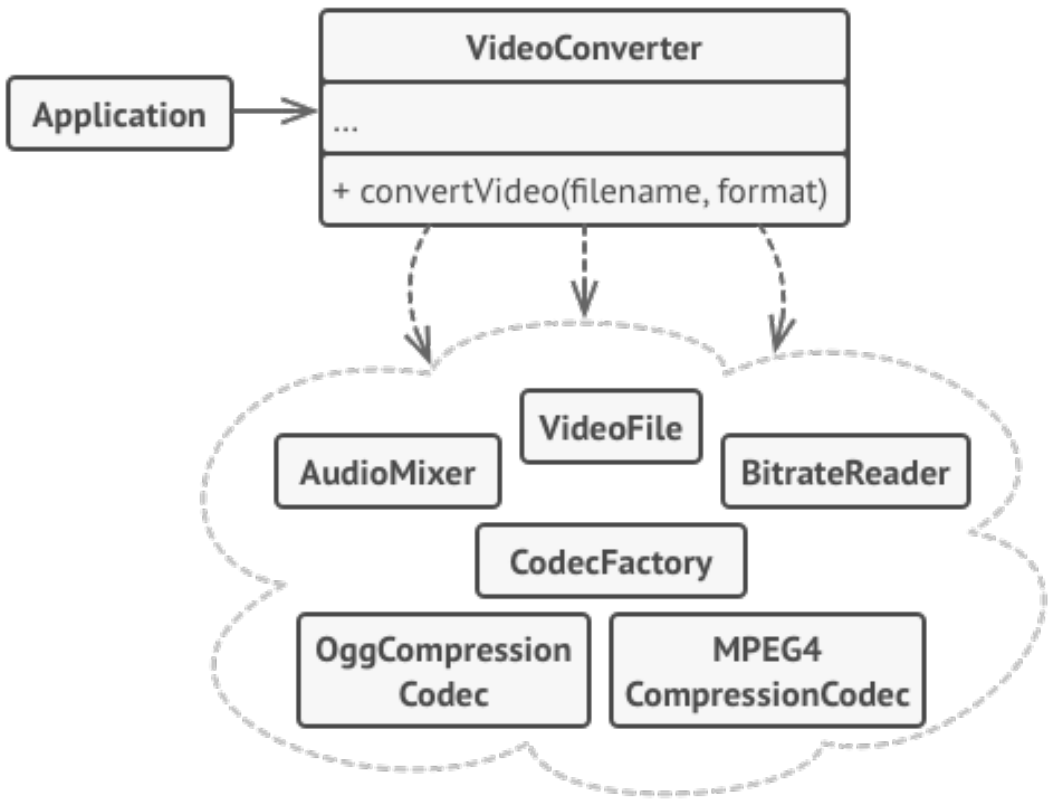
What if a new version of this library is suddenly broken?

What if you find a better library?

Structural Example: Facade

Solution

Use a facade class which provides a simple interface to the library code.

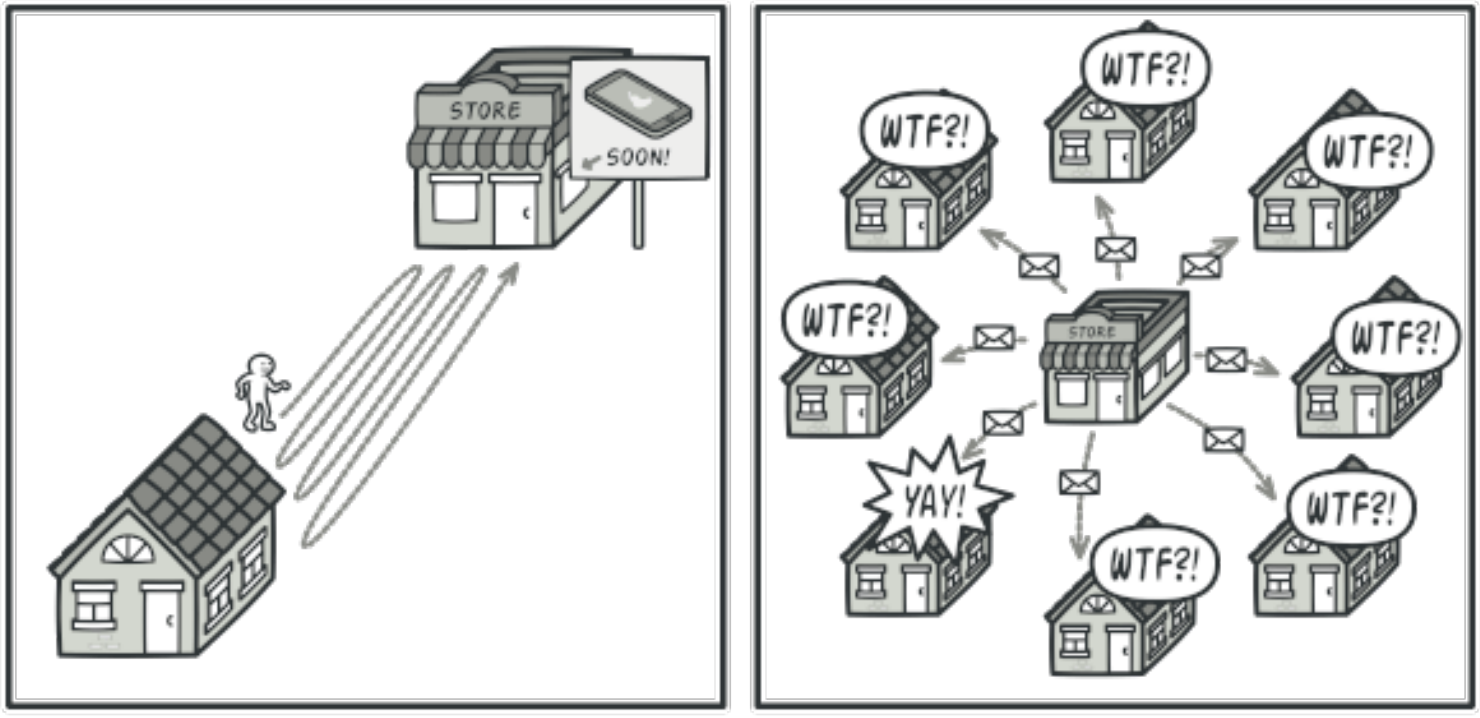


Source: https://refactoring.guru/design-patterns/facade

Behavioural Example: Observer

Problem

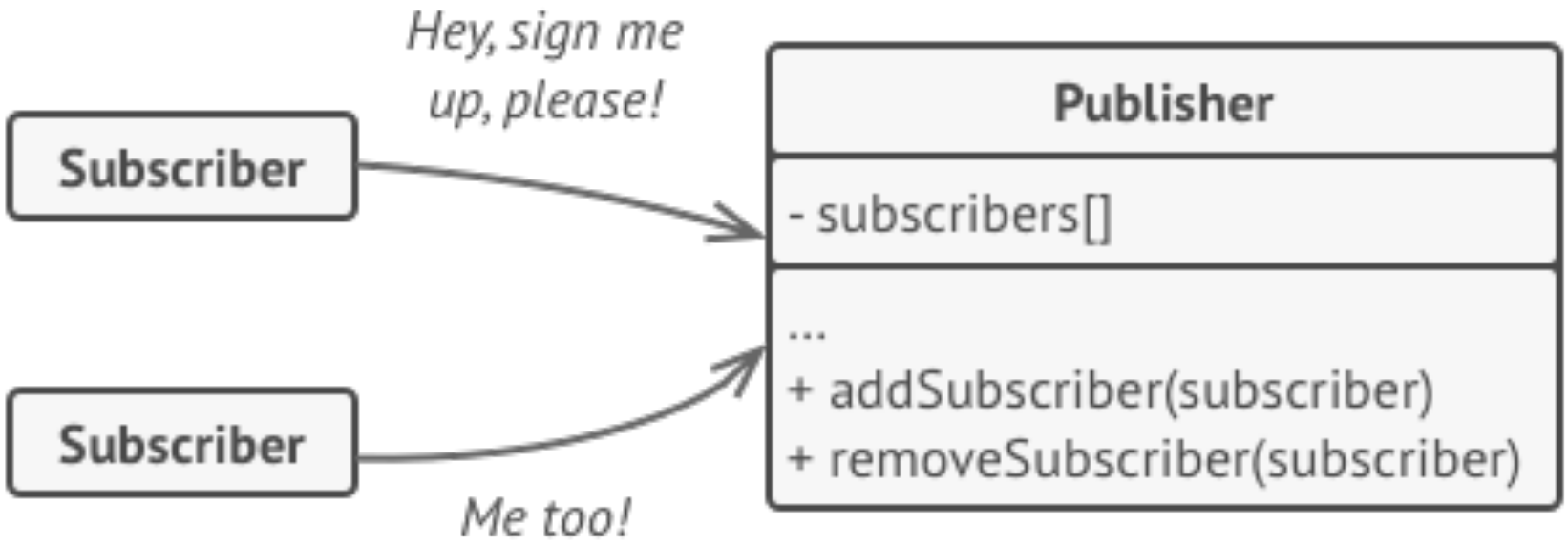
How to best communicate events between classes?



Source: https://refactoring.guru/design-patterns/observer

Behavioural Example: Observer

Solution



Source: https://refactoring.guru/design-patterns/observer

Design Pattern Catalog

A large catalog of common design patterns exists:

`https://refactoring.guru/design-patterns/catalog`

Reading

Books

- **Objects First** *Chapter 8*
- **Effective Java** by Joshua Bloch
- **Design Patterns: Elements of Reusable Object-Oriented Software** by Erich Gamma, Ralph Johnson, John Vlissides, Richard Helm

Web Resources

- `https://refactoring.guru/design-patterns`