School of Computing
FACULTY OF ENGINEERING & PHYSICAL SCIENCES

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COMP5911M
Advanced Software Engineering

8: More Design Patterns

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Last Time

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We introduced the design pattern as

- A named, well-understood solution to a common object-oriented design problem
- A tried-and-tested approach
- A formalisation of experience-based knowledge
- A way for novices to learn to be experts, by example

Last Time

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- We explored a hypothetical scenario where the **Strategy** pattern provides a good solution
- We saw an example of how Strategy is used in practice, for component layout in Java's Swing UI framework
- We introduced the **Observer** pattern and saw how it forms the basis for the event handling model in Swing

Objectives

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- To explore some more design patterns
- To see examples of where these patterns are used

Object Creation

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Our game might have code like this in lots of places:

```
GameCharacter character;
...
if (characterType.equals("soldier")) {
  character = new Soldier();
}
else if (characterType.equals("bandit")) {
  character = new Bandit();
}
else if (characterType.equals("farmer")) {
  character = new Farmer();
}
```

What is the problem here?

Design Principle

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Where possible, classes should be **open for extension but closed for modification**.

In other words, it should be possible to extend our design to incorporate new behaviour without having to modify existing code…

Simple Factories

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```
public class CharacterFactory {
  public GameCharacter makeCharacter(String type) {
    if (type.equals("soldier")) {
      return new Soldier();
    }
    else if (type.equals("bandit")) {
      return new Bandit();
    }
    ...
  }
}
```

we are still using `new` to instantiate concrete classes, but have localized this to the factory class…

Using The Factory

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```
public class GameEngine {
  private CharacterFactory factory;

  public GameEngine(CharacterFactory factory) {
    this.factory = factory;
  }

  public void setUpGame() {
    ...
    GameCharacter chr = factory.makeCharacter(chrType);
  }
}
```

no explicit references here to the actual class being instantiated!

We Need To Go Further…

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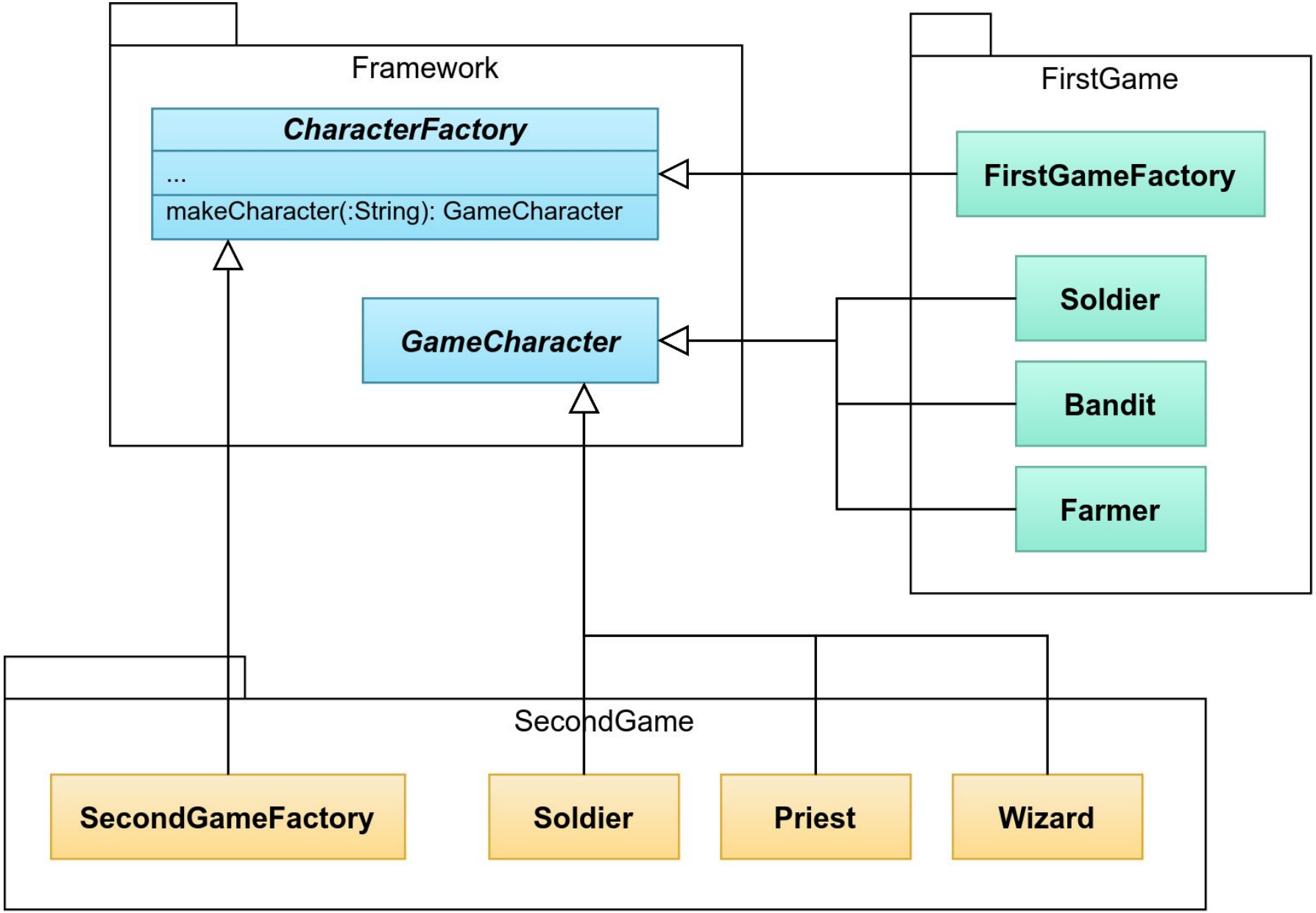
- If we are using this same approach across multiple games, we might need different factories – each knowing how to create a *different* set of `GameCharacter` objects
- It therefore makes sense to insulate our game code from dependency on a specific factory
- … which means we need another interface (or abstract class) to hide our factory classes


Framework
CharacterFactory
...
makeCharacter(:String): GameCharacter
GameCharacter
FirstGame
FirstGameFactory
Soldier
Bandit
Farmer
SecondGame
SecondGameFactory
Soldier
Priest
Wizard

Using `GameEngine`

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```
public class FirstGame {
  private GameEngine engine;

  public FirstGame() {
    CharacterFactory factory = new FirstGameFactory();
    engine = new GameEngine(factory);
    ...
  }
  ...
}
```

same `GameEngine` can be used in all games; we just need to plug in the appropriate factory object…

The Factory Method Pattern

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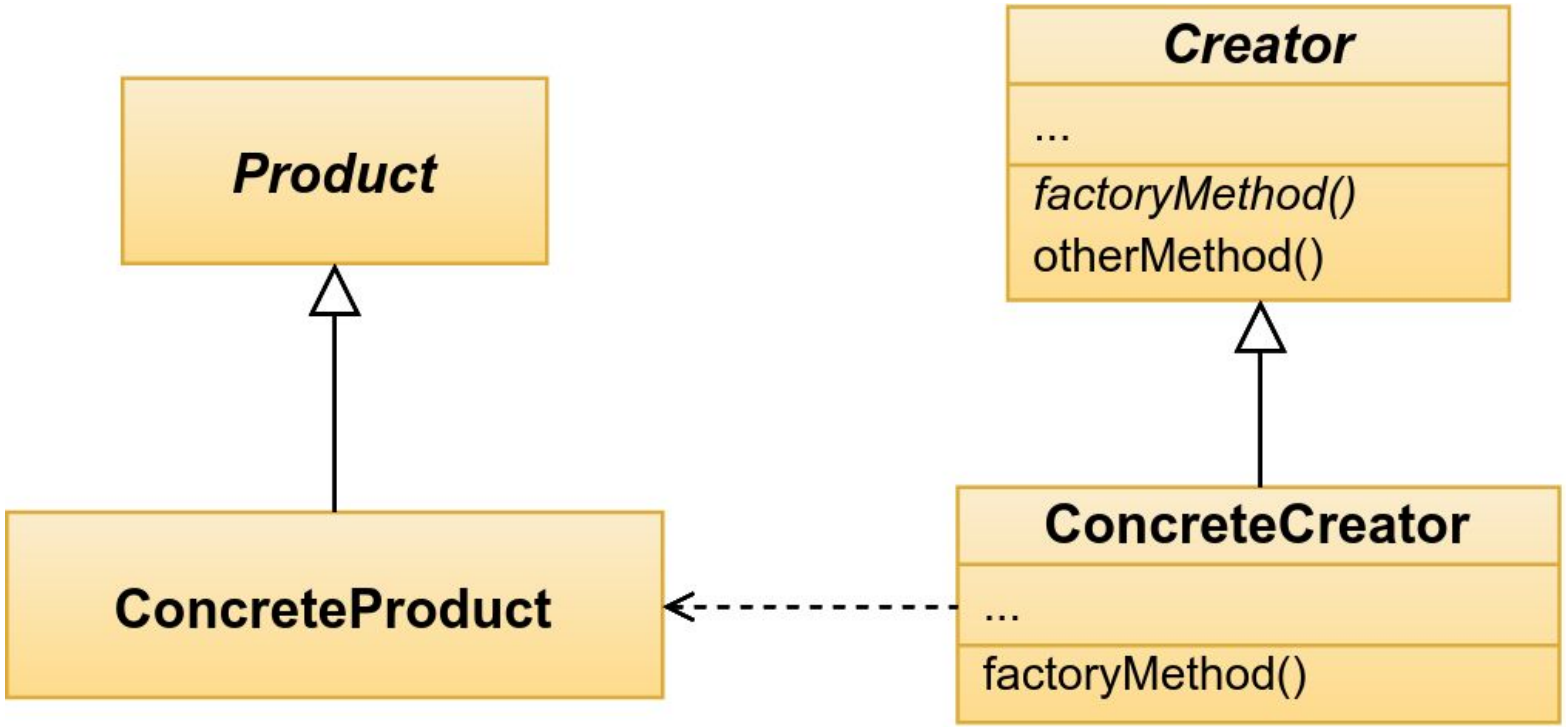

More Patterns

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- Decorator
- Façade
- Composite

Decorator

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- **Delegation pattern**: a class has methods that forward calls to identical methods supplied by another class
- Behaviour of an object is modified dynamically by ‘wrapping other objects around it’
- Decorator and recipient of decoration have same interface, so decoration is transparent

Example: Java Swing

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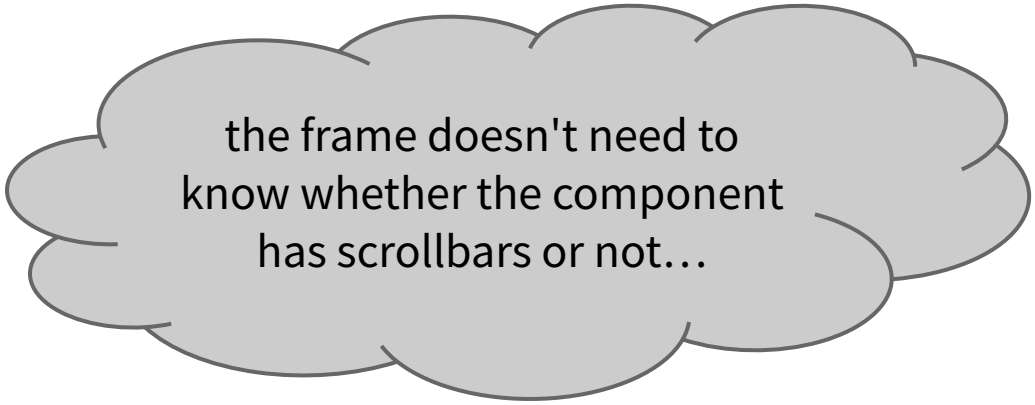
```
JLabel view = new JLabel(new ImageIcon(image));
JFrame frame = new JFrame(filename);

// no decoration
frame.add(view);

// scrollbars as decoration
frame.add(new JScrollPane(view));
```



Example: Java I/O

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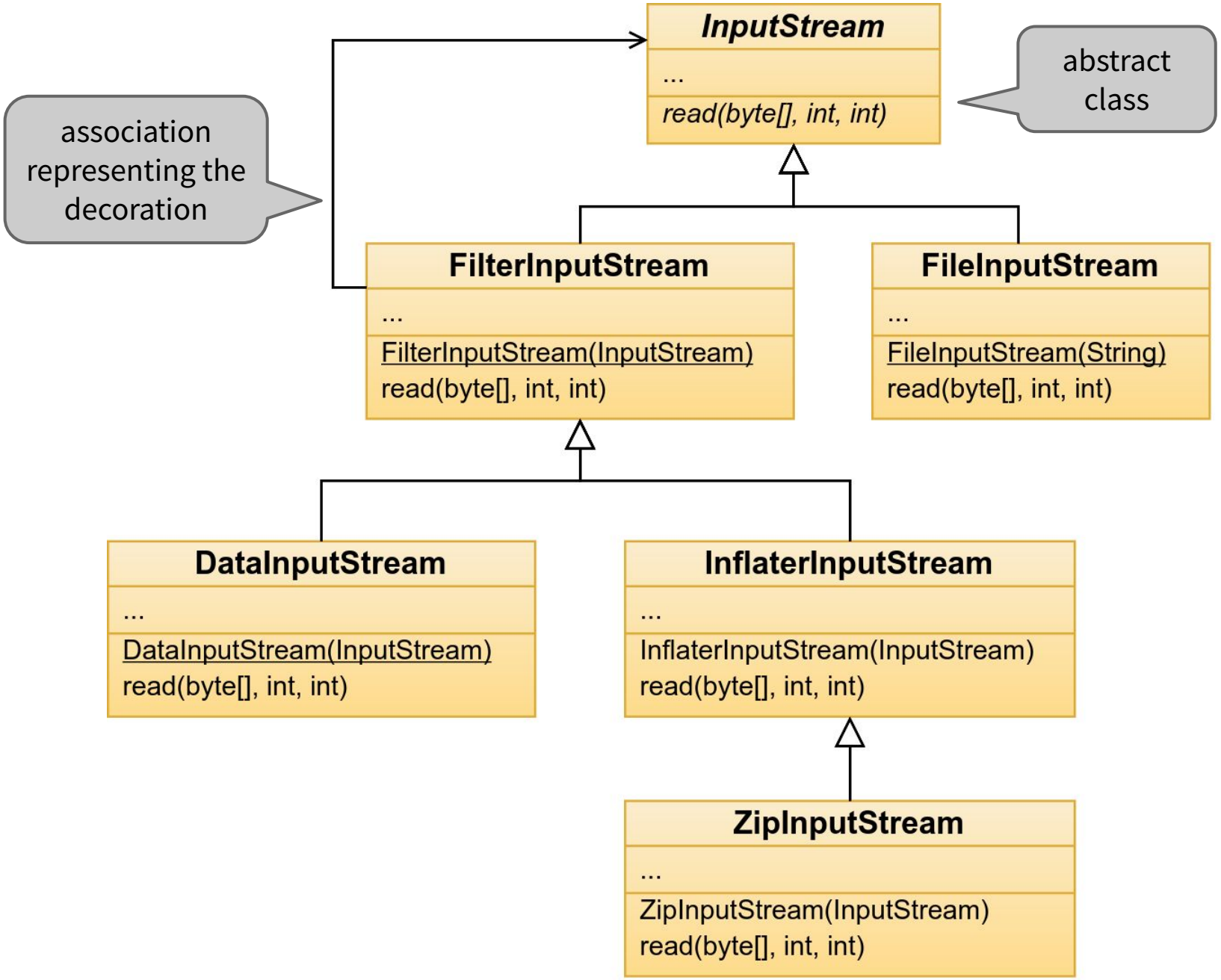
- I/O streams can vary in many ways
  - Binary or text-based
  - Buffered or unbuffered
  - Compressed or uncompressed…
- We would like to support this variation
- BUT having a class for every possible combination of stream attributes ⇒ *huge* library of I/O classes!


InputStream
...
read(byte[], int, int)
abstract class
association representing the decoration
FilterInputStream
...
FilterInputStream(InputStream)
read(byte[], int, int)
FileInputStream
...
FileInputStream(String)
read(byte[], int, int)
DataInputStream
...
DataInputStream(InputStream)
read(byte[], int, int)
InflaterInputStream
...
InflaterInputStream(InputStream)
read(byte[], int, int)
ZipInputStream
...
ZipInputStream(InputStream)
read(byte[], int, int)

Example: Java I/O

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```
DataInputStream in =
    new DataInputStream(
        new ZipInputStream(
            new FileInputStream("foo.zip")
        )
    );
...
byte[] data = new byte[NUM_BYTES];
in.read(data, 0, NUM_BYTES);
```

what happens when `read` method is called?

Example: Java I/O

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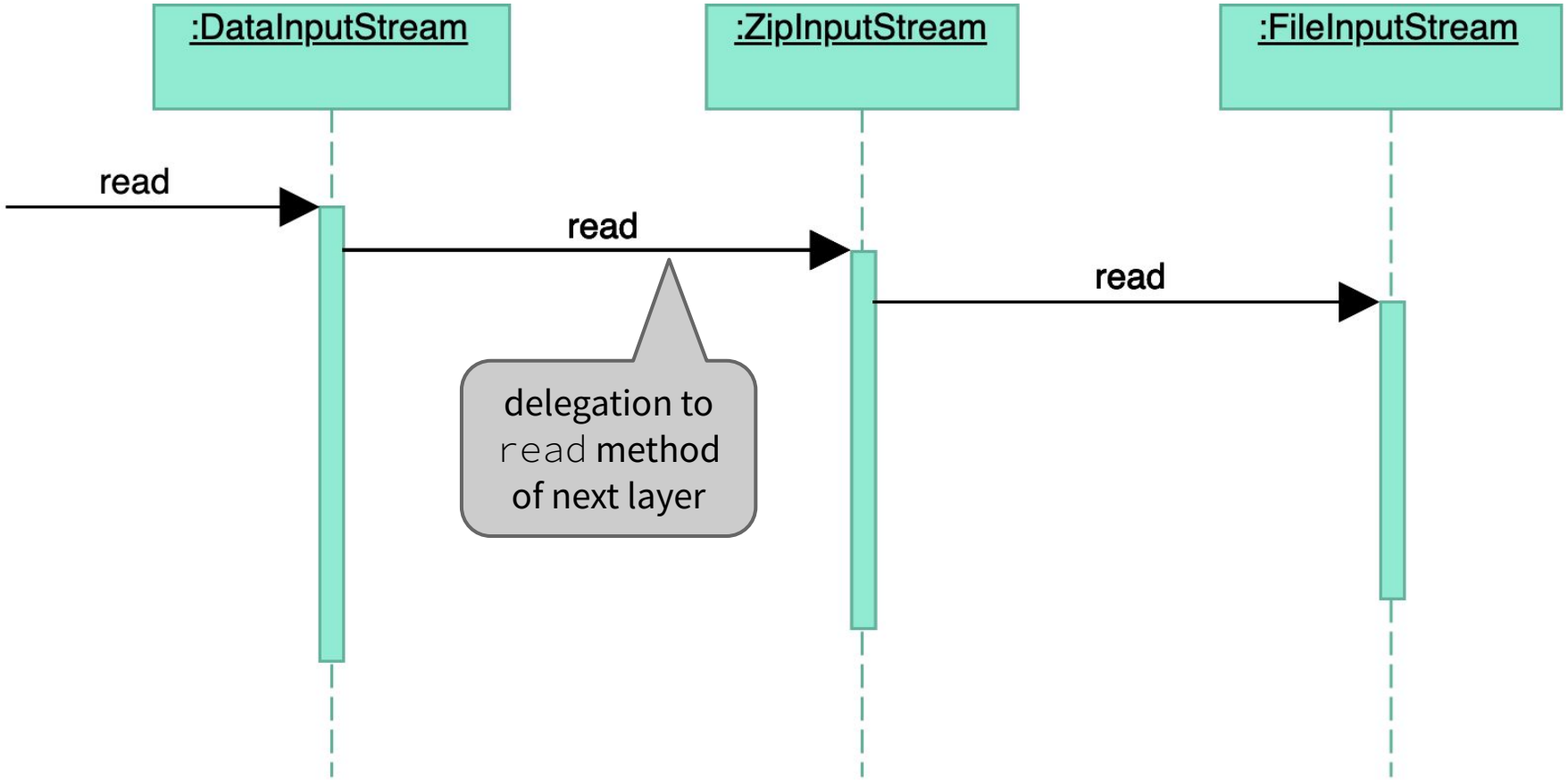

(This is a UML **sequence diagram**)

Façade

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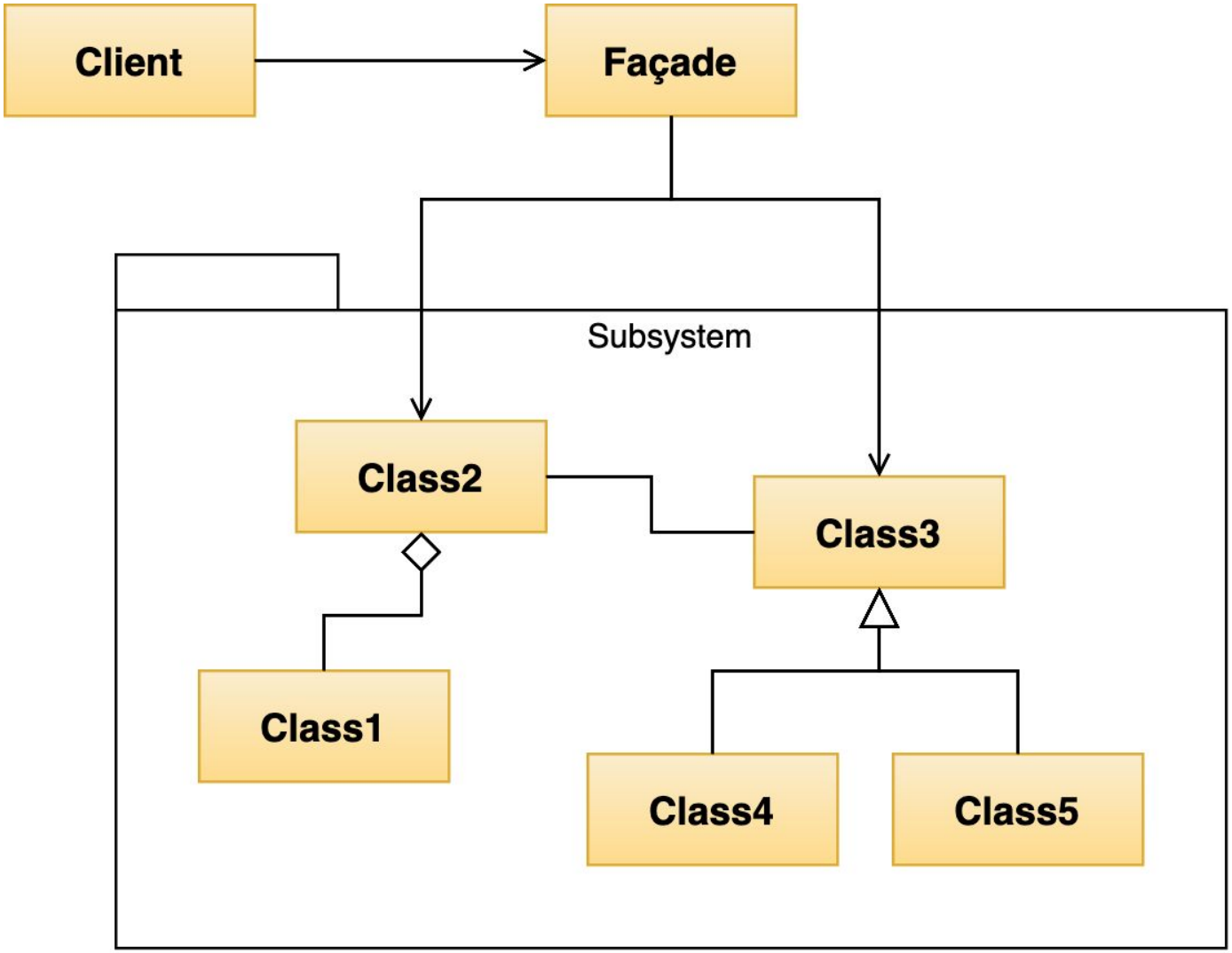
Problem

- Complex subsystem (multiple classes)
- Subsystem implementation could change
- Clients of subsystem need a simplified view of subsystem and a coherent, stable entry point

Solution

- Define a façade class, providing a new & simpler interface
- Façade methods expose desired portion of subsystem functionality to clients, by delegation
- Subsystem classes know nothing about façade, and client need know nothing about subsystem classes

Façade


Client
Façade
Subsystem
Class2
Class3
Class1
Class4
Class5

Composite

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Deals with problems in which

- Objects can be grouped together
- Groups can contain other groups (tree-like hierarchy)

Requires

- One or more **leaf** classes
- A **composite** class, representing a collection of leaf and other composite objects
- An interface implemented by, or abstract superclass of, leaf and composite classes

Composite Example

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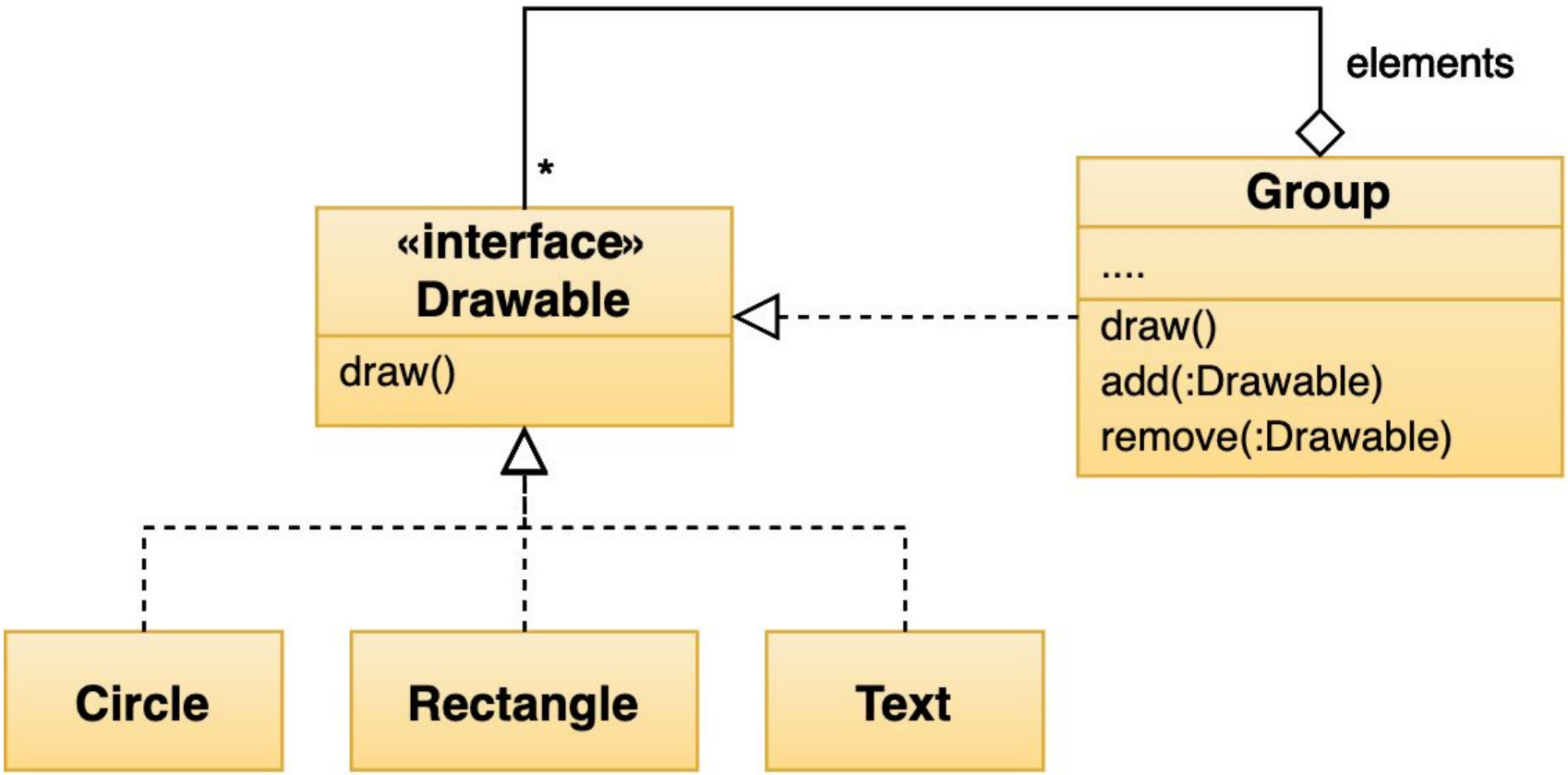

Summary

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We have

- Discussed how we can decouple code from specific knowledge about the objects it is using via the **Factory Method** pattern
- Seen how **Decorator** allows us to add functionality to objects in a transparent way
- Noted that **Façade** gives us a stable, simplified view of a complex and changeable subsystem
- Seen that **Composite** gives us a way of managing hierarchical groups of objects

Follow-Up / Further Reading

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- Gamma et al, *Design Patterns: Elements of Reusable Software*
- Refactoring Guru's Catalog of Design Patterns
- Example code from this lecture