Design Patterns

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Definition, Solutions and Elements

What Are Design Patterns?

- **General** and **reusable solutions** to common problems in software design
- A **template** for solving given problems
- Add additional layers of **abstraction** in order to reach flexibility

What Do Design Patterns Solve?

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- Patterns solve **software structural problems** like:
  - Abstraction
  - Encapsulation
  - Separation of concerns
  - Coupling and cohesion
  - Separation of interface and implementation

Elements of a Design Pattern

- Pattern name - Increases **vocabulary** of designers
- Problem - **Intent**, context and when to apply
- Solution - **Abstract** code
- Consequences - **Results** and trade-offs

Benefits and Drawbacks

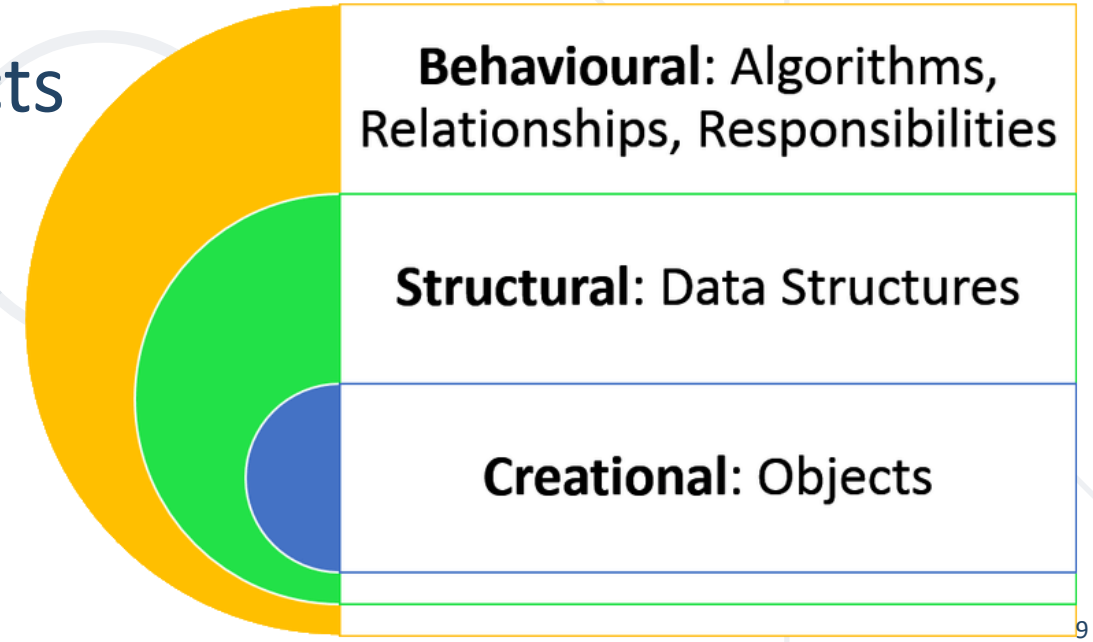
- Benefits
  - Names form a common vocabulary
  - Enable large-scale **reuse** of software architectures
  - Help improve developer **communication**
  - Can **speed-up** the development
- Drawbacks
  - Deceptively simple
  - Developers may suffer from **pattern overload** and **overdesign**
  - Validated by **experience** and discussion, not by automated testing

Should be used only if **understood well**

Types of Design Patterns

Main Types

- **Creational** patterns
  - Deal with **initialization and configuration** of classes and objects
- **Structural** patterns
  - Describe ways to **assemble** objects to implement **new functionality**
  - **Composition** of classes and objects
- **Behavioral** patterns
  - Deal with dynamic **interactions**
  - among societies of classes
  - Distribute **responsibility**



Types

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	Purpose		
	Creational (5)	Structural (7)	Behavioral (11)
Class	Factory Method	Adapter	Interpreter Template Method
Object	Abstract Factory Builder Prototype Singleton	Adapter Bridge Composite Decorator Façade Flyweight Proxy	Chain of Responsibility Command Iterator Mediator Memento Observer State Strategy Visitor

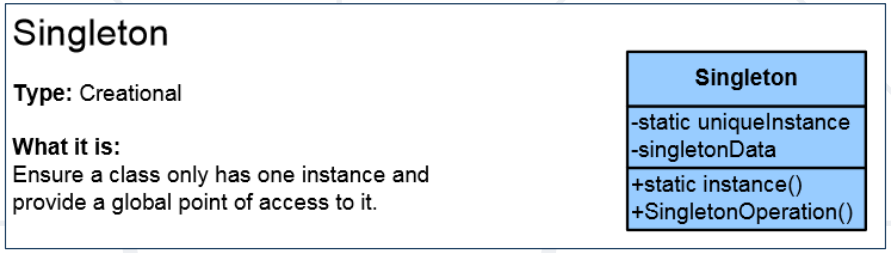
Creational Patterns

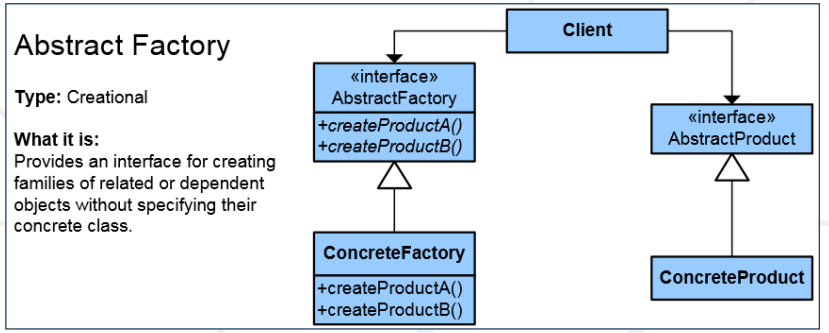
Purposes

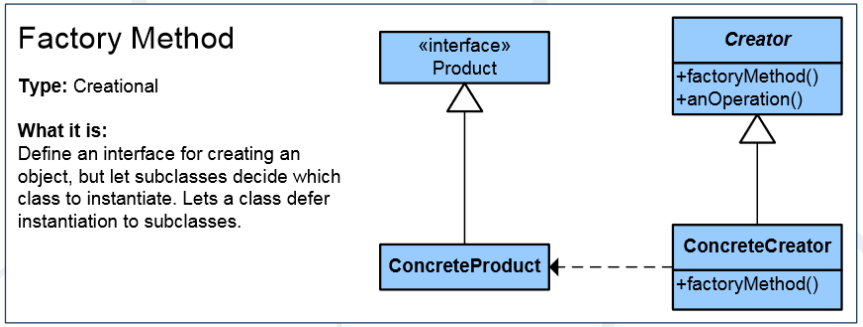
- Deal with **object creation** mechanisms
- Trying to create objects in a **manner suitable** to the **situation**
- Two main ideas
  - **Encapsulating** knowledge about which classes the system uses
  - **Hiding** how instances of these classes are created

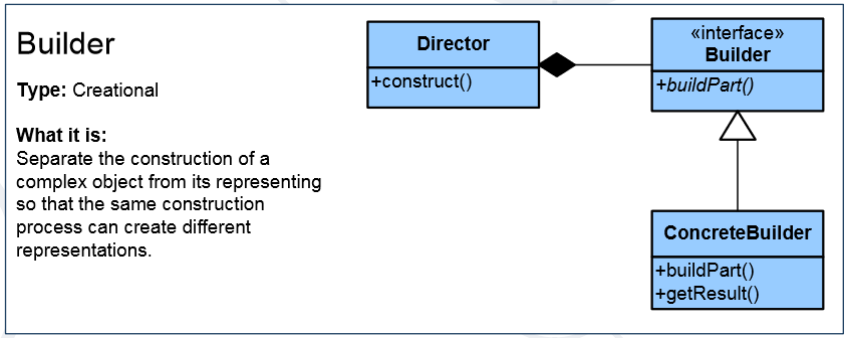
List of Creational Patterns

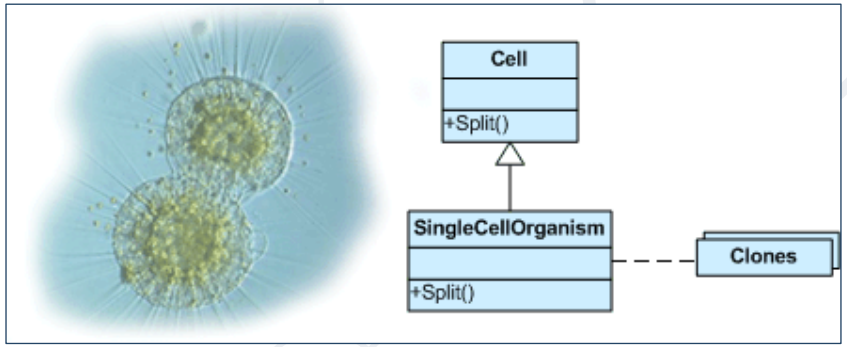
- Singleton
- Simple Factory
- Factory Method
- Abstract Factory
- Builder
- Prototype
- Fluent Interface
- Object Pool
- Lazy Initialization





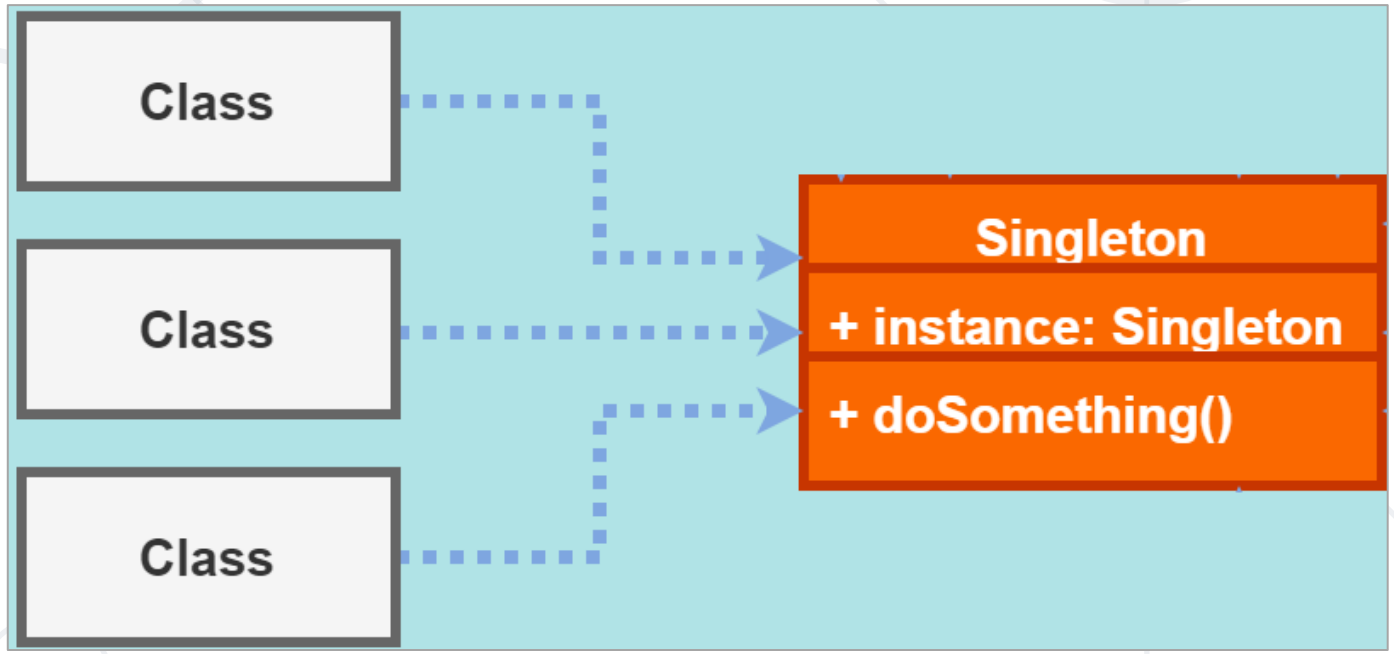






Singleton Pattern

- The most often used creational design pattern
- A Singleton class is supposed to have **only one instance**
- It is **not a global variable**
- Possible problems
  - Lazy loading
  - Thread-safe



Double-Check Singleton Example

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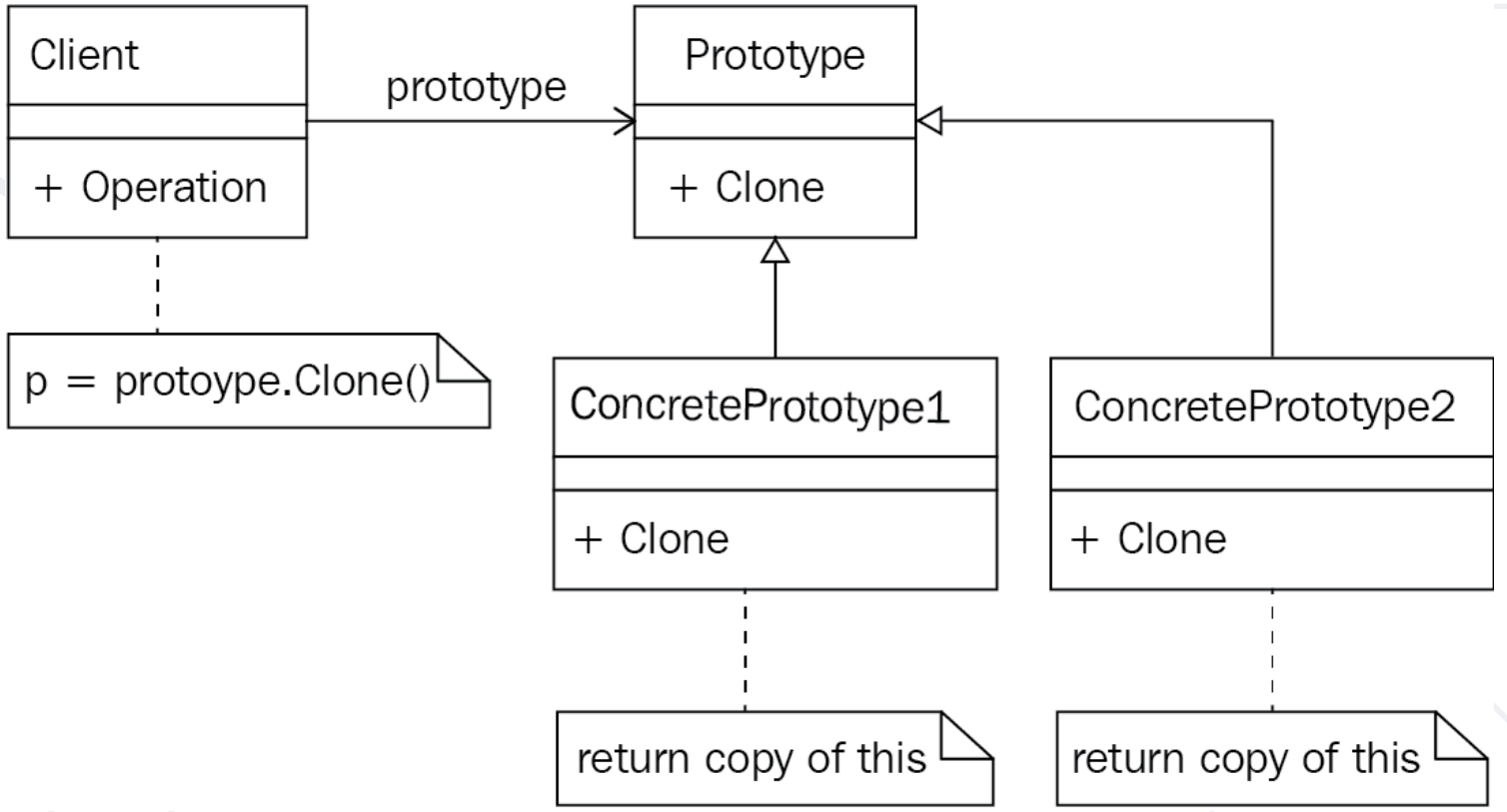
```
public sealed class Singleton {
  private static Singleton instance;
  private Singleton() { }
  public static Singleton Instance {
    get {
      if (instance == null) {
        lock (instance) {
          if (instance == null)
            instance = new Singleton(); } }
      return instance; } } }
```

Prototype Pattern

- Factory for **cloning** new instances from a prototype
  - Create new objects by copying this prototype instead of using the "new" keyword
- **ICloneable** interface

  acts as Prototype



The Prototype Abstract Class

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```
abstract class Prototype
{
  private string _id;

  public Prototype(string id)
  {
    this._id = id;
  }

  public string Id => this._id;

  public abstract Prototype Clone();
}
```

A Concrete Prototype Class

Software University

```
class ConcretePrototype : Prototype
{
  public ConcretePrototype(string id) : base(id) { }

  public override Prototype Clone()
    => return (Prototype)this.MemberwiseClone();
}
```

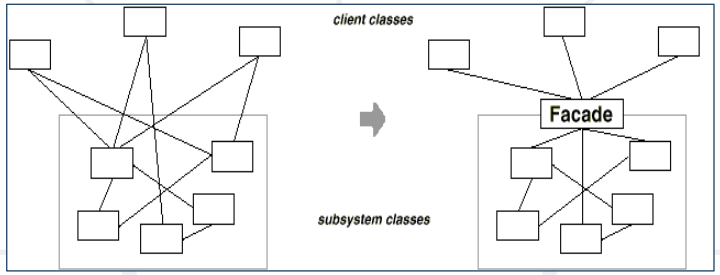
Structural Patterns

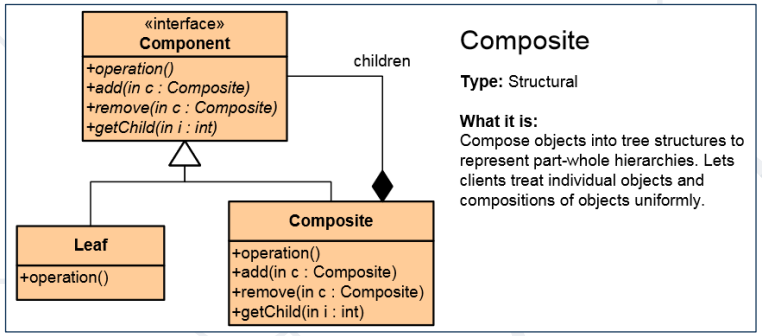
Purposes

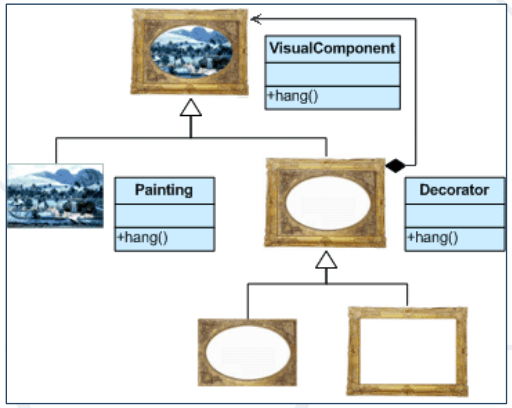
- Describe ways to assemble **objects** to implement a **new functionality**
- Ease the design by identifying a simple way to realize **relationship** between entities
- All about Class and Object composition
  - **Inheritance** to compose interfaces
  - Ways to compose objects to obtain **new functionality**

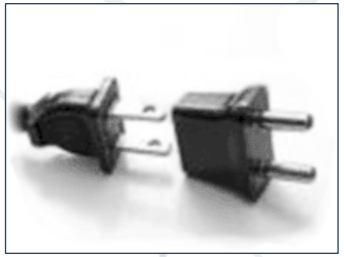
List of Structural Patterns

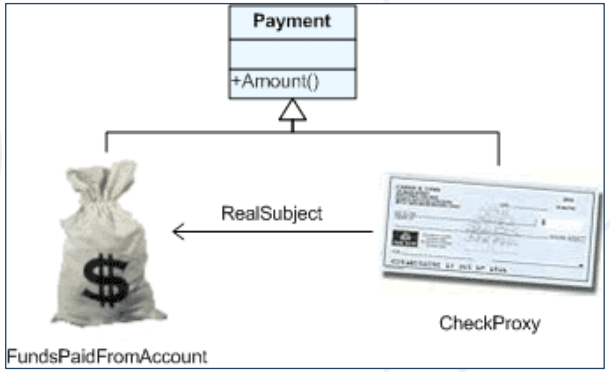
- Façade
- Composite
- Flyweight
- Proxy
- Decorator
- Adapter
- Bridge

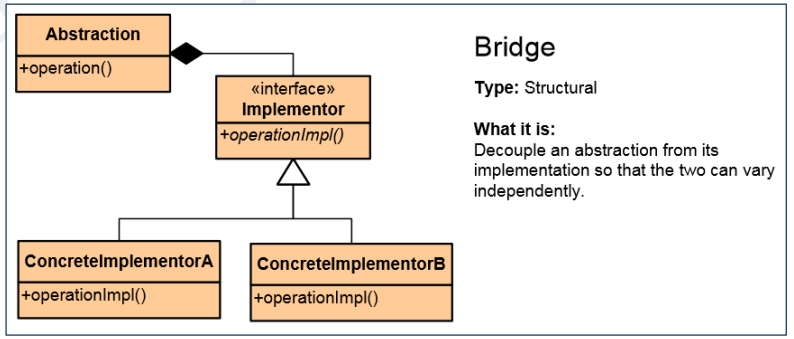






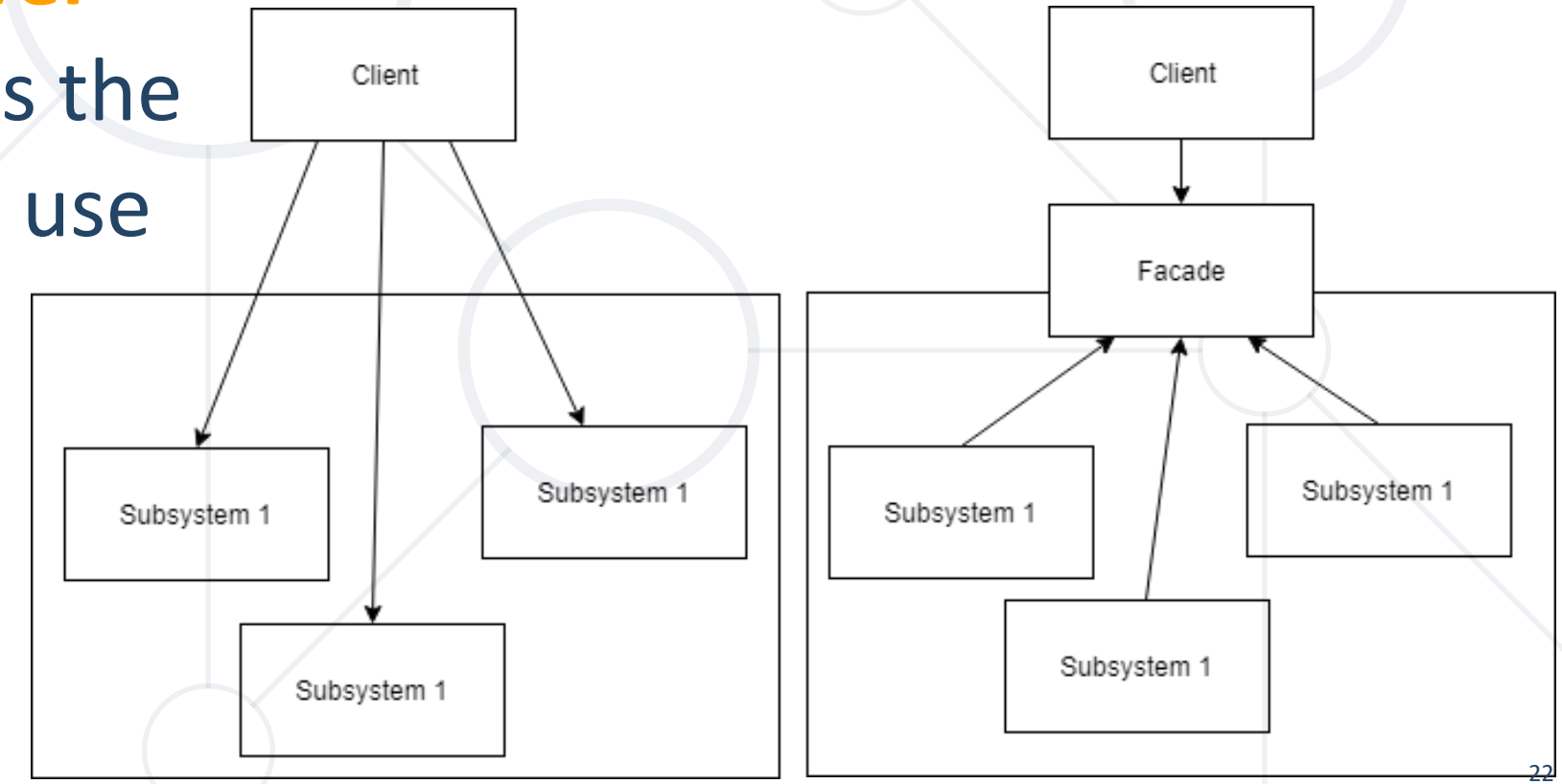






Façade Pattern

- Provides a **unified interface** to a set of interfaces in a subsystem
- Defines a **higher-level interface** that makes the subsystem easier to use



The Façade Class (1)

```
class Facade
{
  private SubSystemOne _one;
  private SubSystemTwo _two;

  public Facade()
  {
    _one = new SubSystemOne();
    _two = new SubSystemTwo();
  }
```

The Façade Class (2)

```
    public void MethodA()
    {
        Console.WriteLine("\nMethodA() ---- ");
        _one.MethodOne();
        _two.MethodTwo();
    }

    public void MethodB()
    {
        Console.WriteLine("\nMethodB() ---- ");
        _two.MethodTwo();
    }
}
```

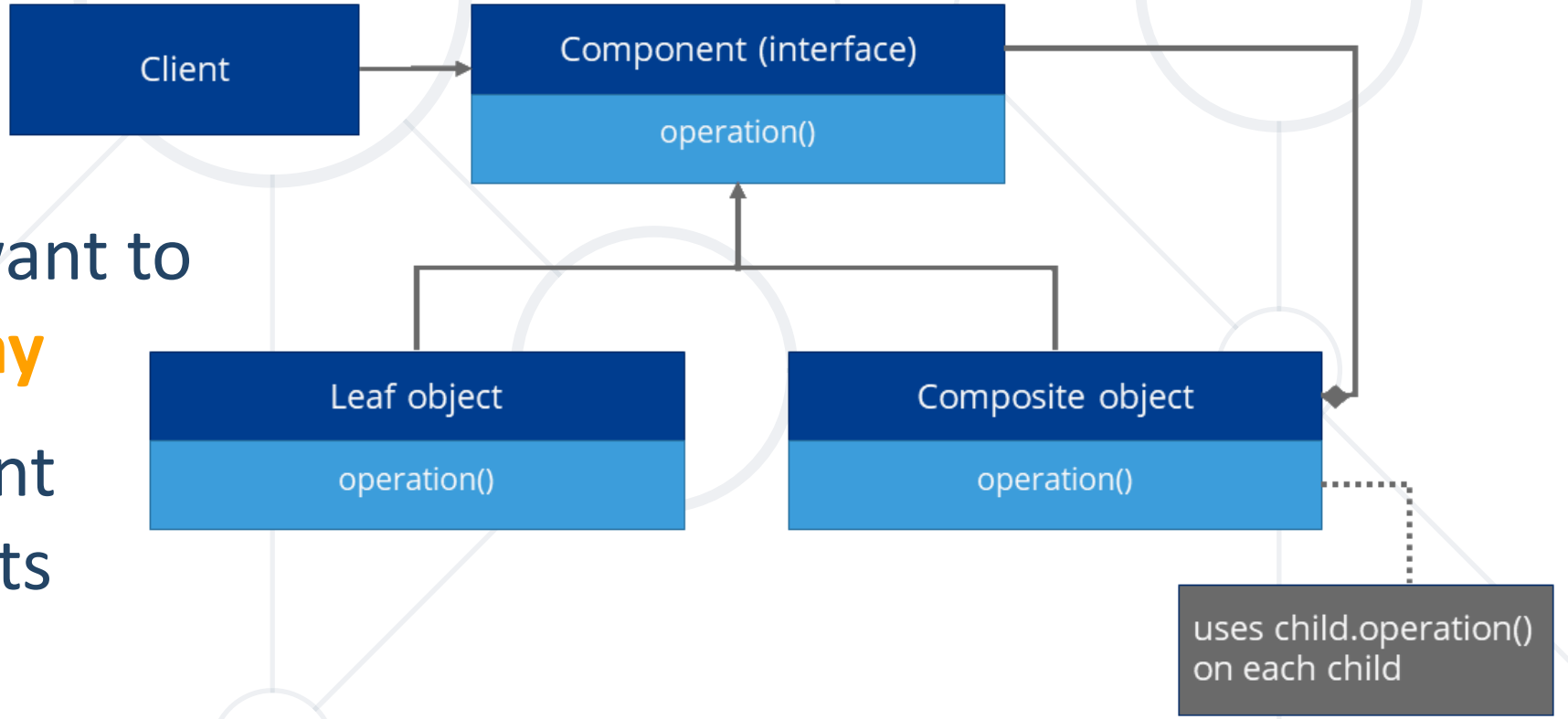
Subsystem Classes

```
class SubSystemOne
{
  public void MethodOne()
    => Console.WriteLine("SubSystemOne Method");
}
```

```
class SubSystemTwo
{
  public void MethodTwo()
    => Console.WriteLine("SubSystemTwo Method");
}
```

Composite Pattern

- Allows to **combine** different types of objects in tree structures
- Gives the possibility to treat the **same object(s)**
- Used when
  - You have different objects that you want to **treat the same way**
  - You want to present **hierarchy** of objects



The Component Abstract Class

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```
abstract class Component
{
  protected string name;

  public Component(string name)
  {
      this.name = name;
  }

  public abstract void Add(Component c);
  public abstract void Remove(Component c);
  public abstract void Display(int depth);
}
```

The Composite Class (1)

```
class Composite : Component
{
  private List<Component> _children = new List<Component>();

  public Composite(string name) : base(name) { }

  public override void Add(Component component)
      => _children.Add(component);

  public override void Remove(Component component)
      => _children.Remove(component);
```

The Composite Class (2)

```
public override void Display(int depth)
  {
    Console.WriteLine(new String('-', depth) + name);

    foreach (Component component in _children)
    {
      component.Display(depth + 2);
    }
  }
}
```

The Leaf Class

```
class Leaf : Component
{
  public Leaf(string name) : base(name) { }

  public override void Add(Component c)
    => Console.WriteLine("Cannot add to a leaf");
  public override void Remove(Component c)
    => Console.WriteLine("Cannot remove from a leaf");
  public override void Display(int depth)
    => Console.WriteLine(new String('-', depth) + name);
}
```

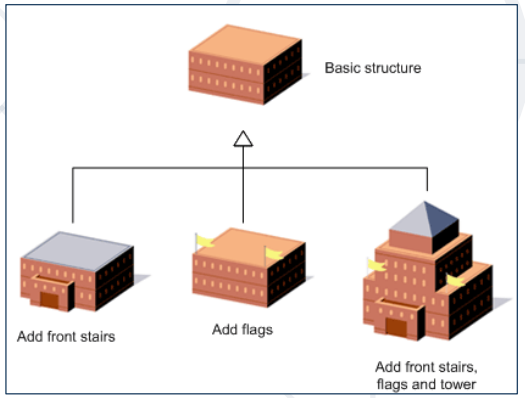
Behavioral Patterns

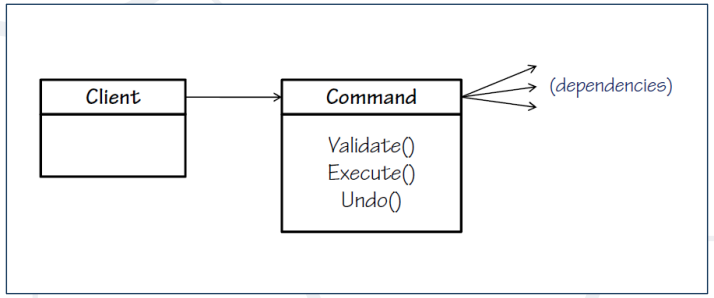
Purposes

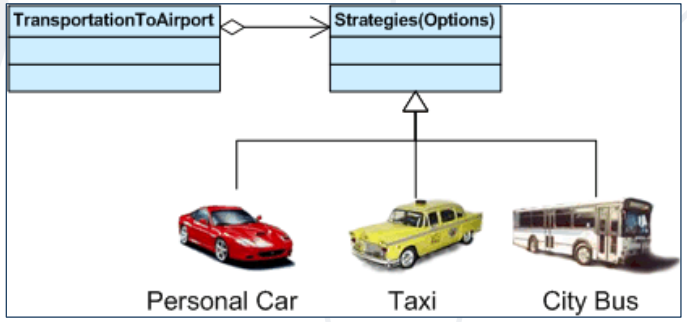
- Concerned with **interaction** between objects
  - Either with the **assignment of responsibilities** between objects
  - Or **encapsulating behavior** in an object and delegating requests to it
- Increases **flexibility** in carrying out cross-classes communication

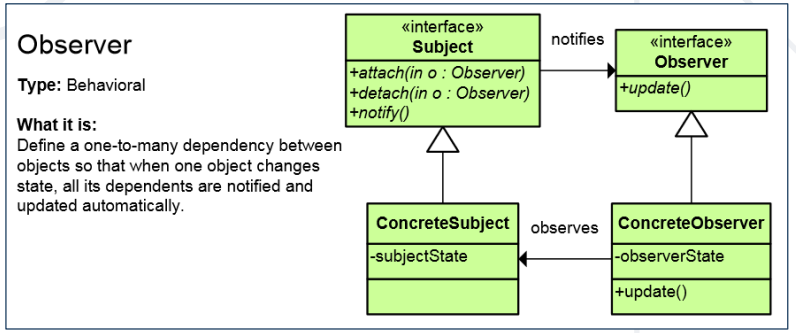
List of Behavioral Patterns (1)

- Chain of Responsibility
- Iterator
- Command
- Template Method
- Strategy
- Observer



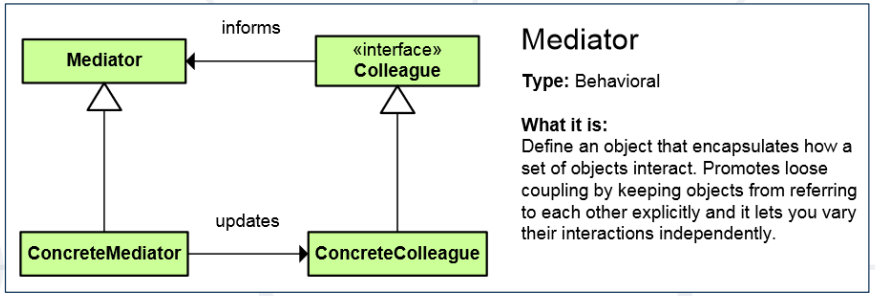


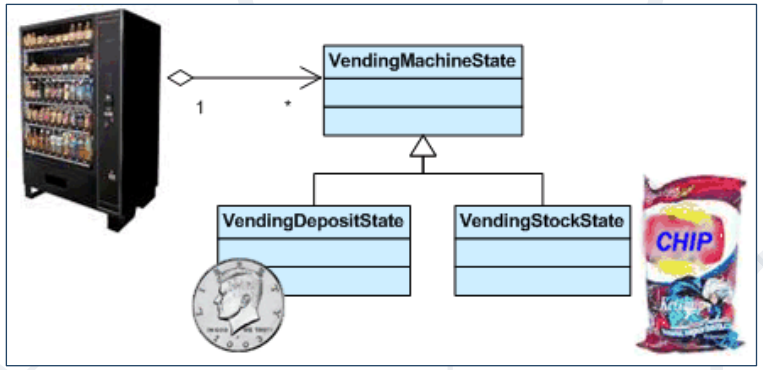


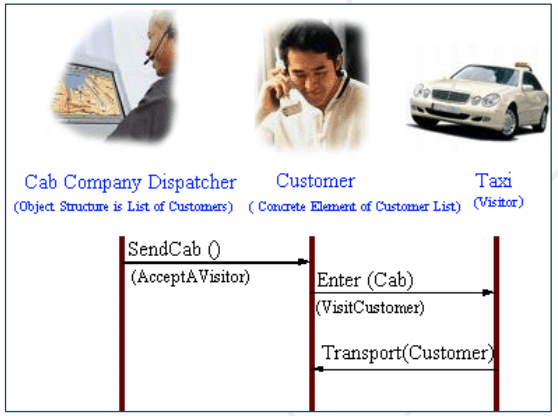


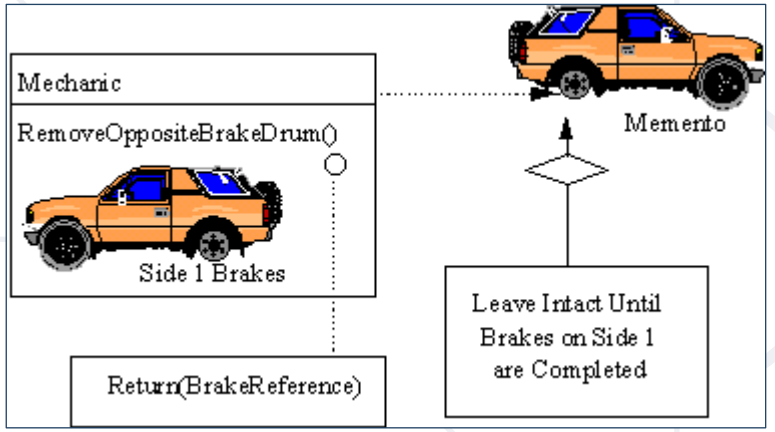
List of Behavioral Patterns (2)

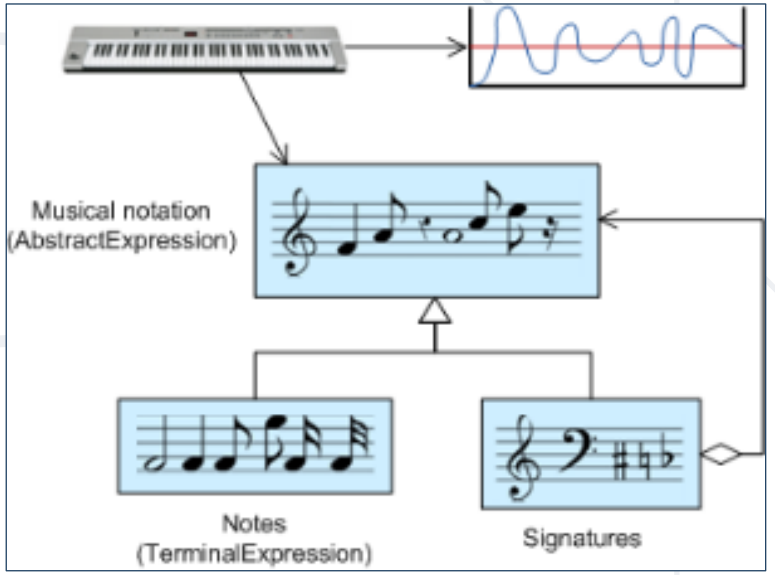
- Mediator
- Memento
- State
- Interpreter
- Visitor





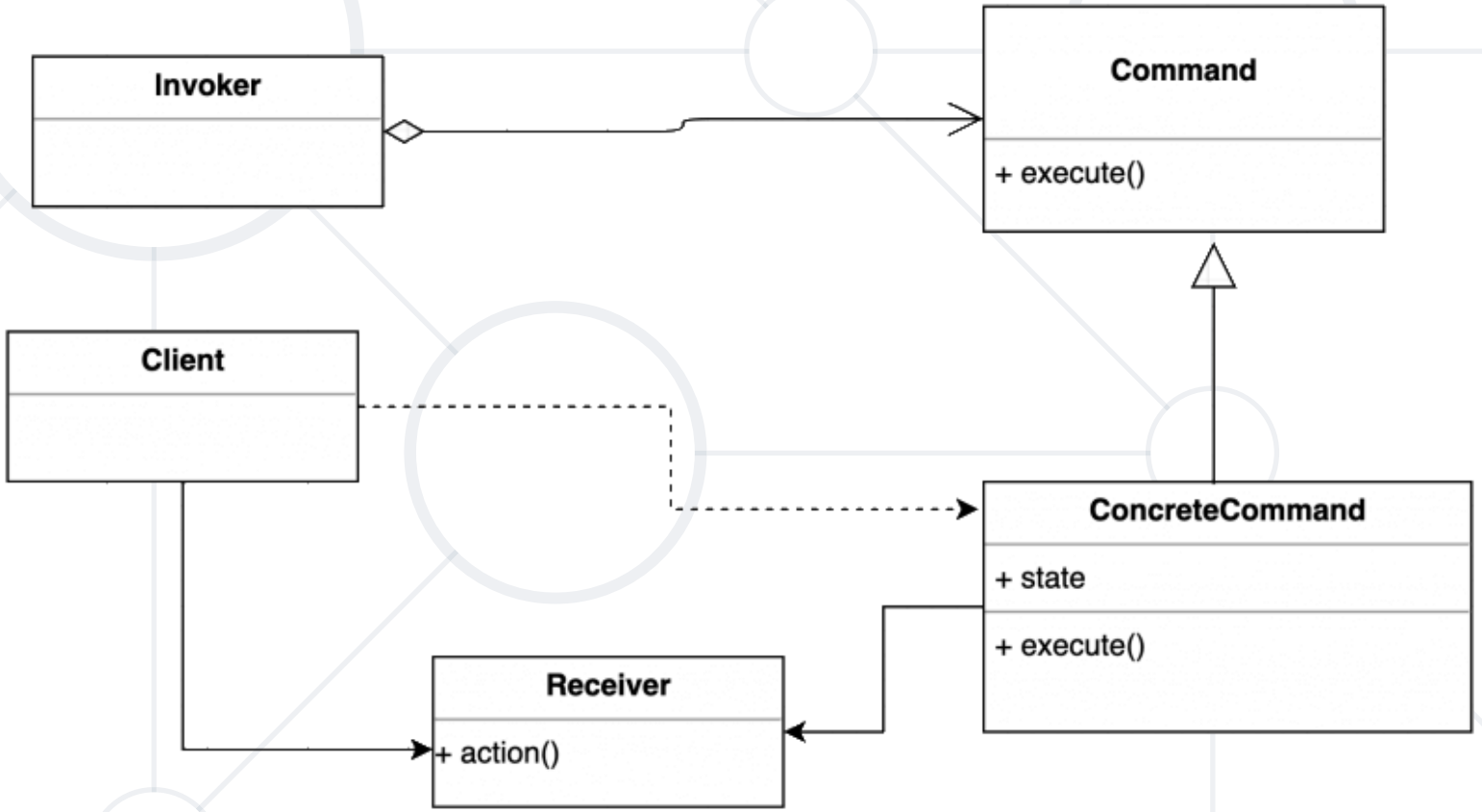






Command Pattern

- An object **encapsulates** all the information needed to call a method at a later time
- Lets you **parameterize** clients with different requests, queue or log requests, and support undoable operations



The Command Abstract Class

```
abstract class Command
{
  protected Receiver receiver;

  public Command(Receiver receiver)
  {
    this.receiver = receiver;
  }

  public abstract void Execute();
}
```

Concrete Command Class

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```
class ConcreteCommand : Command
{
  public ConcreteCommand(Receiver receiver)
    : base(receiver) { }

  public override void Execute()
    => receiver.Action();
}
```

The Receiver Class

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```
class Receiver
{
  public void Action()
  {
    Console.WriteLine("Called Receiver.Action()");
  }
}
```

The Invoker Class

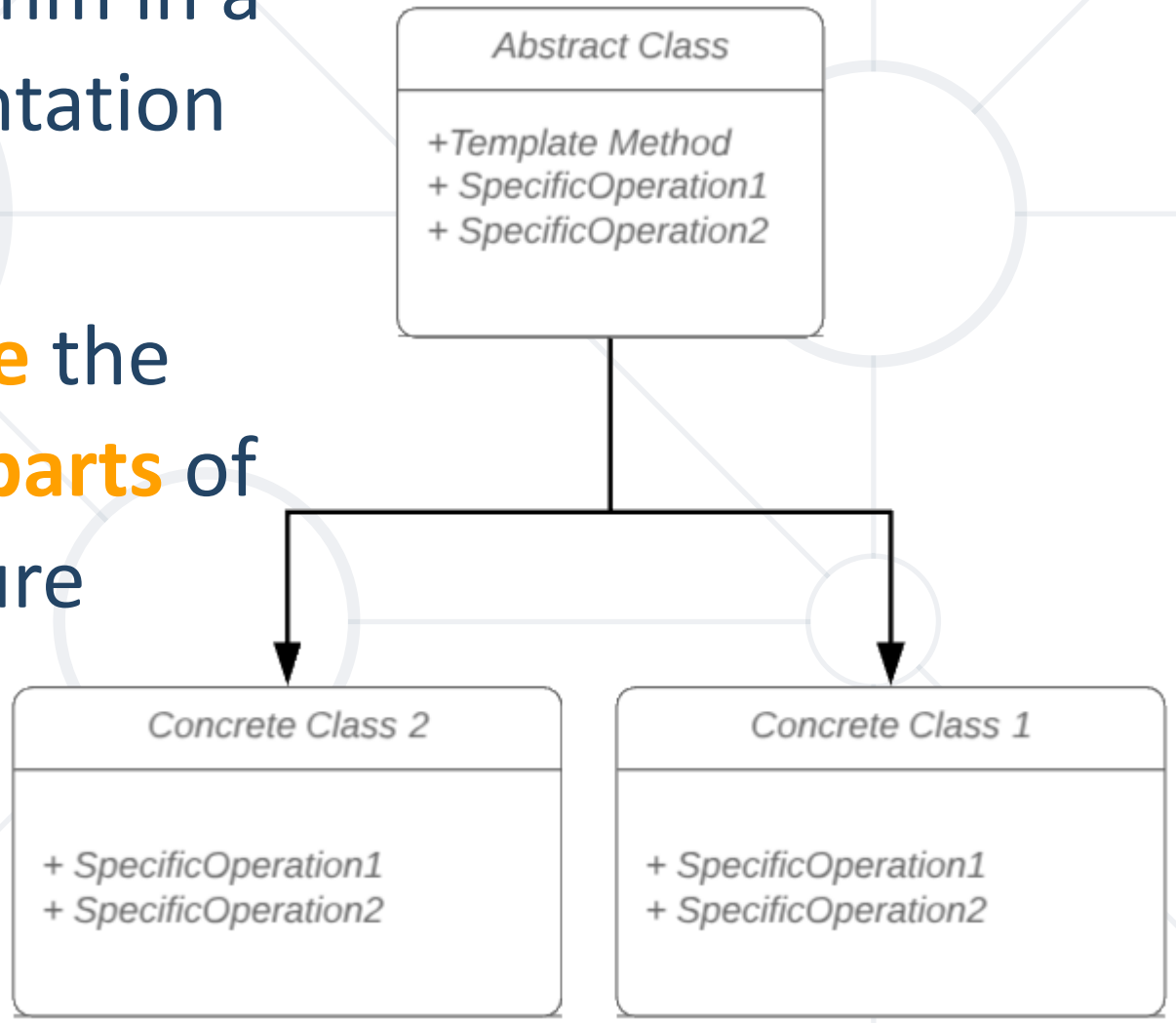
```
class Invoker
{
  private Command _command;

  public void SetCommand(Command command)
    => this._command = command;

  public void ExecuteCommand()
    => _command.Execute();
}
```

Template Method Pattern

- Define the **skeleton** of an algorithm in a method, leaving some implementation to its subclasses
- Allows the subclasses to **redefine** the implementation of some of the **parts** of the algorithm, but not its structure



The Abstract Class

```
abstract class AbstractClass
{
  public abstract void PrimitiveOperation1();
  public abstract void PrimitiveOperation2();

  public void TemplateMethod() {
    PrimitiveOperation1();
    PrimitiveOperation2();
    Console.WriteLine(""); }
}
```

A Concrete Class

```
class ConcreteClassA : AbstractClass
{
  public override void PrimitiveOperation1()
    => Console.WriteLine("ConcreteClassA.
       PrimitiveOperation1()");

  public override void PrimitiveOperation2()
    => Console.WriteLine("ConcreteClassA
       .PrimitiveOperation2()");
}
```

Summary

- **Design Patterns**
  - Provide solution to common problems
  - Add additional layers of **abstraction**
- Three main **types** of Design Patterns
  - Creational
  - Structural
  - Behavioral

Questions?

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