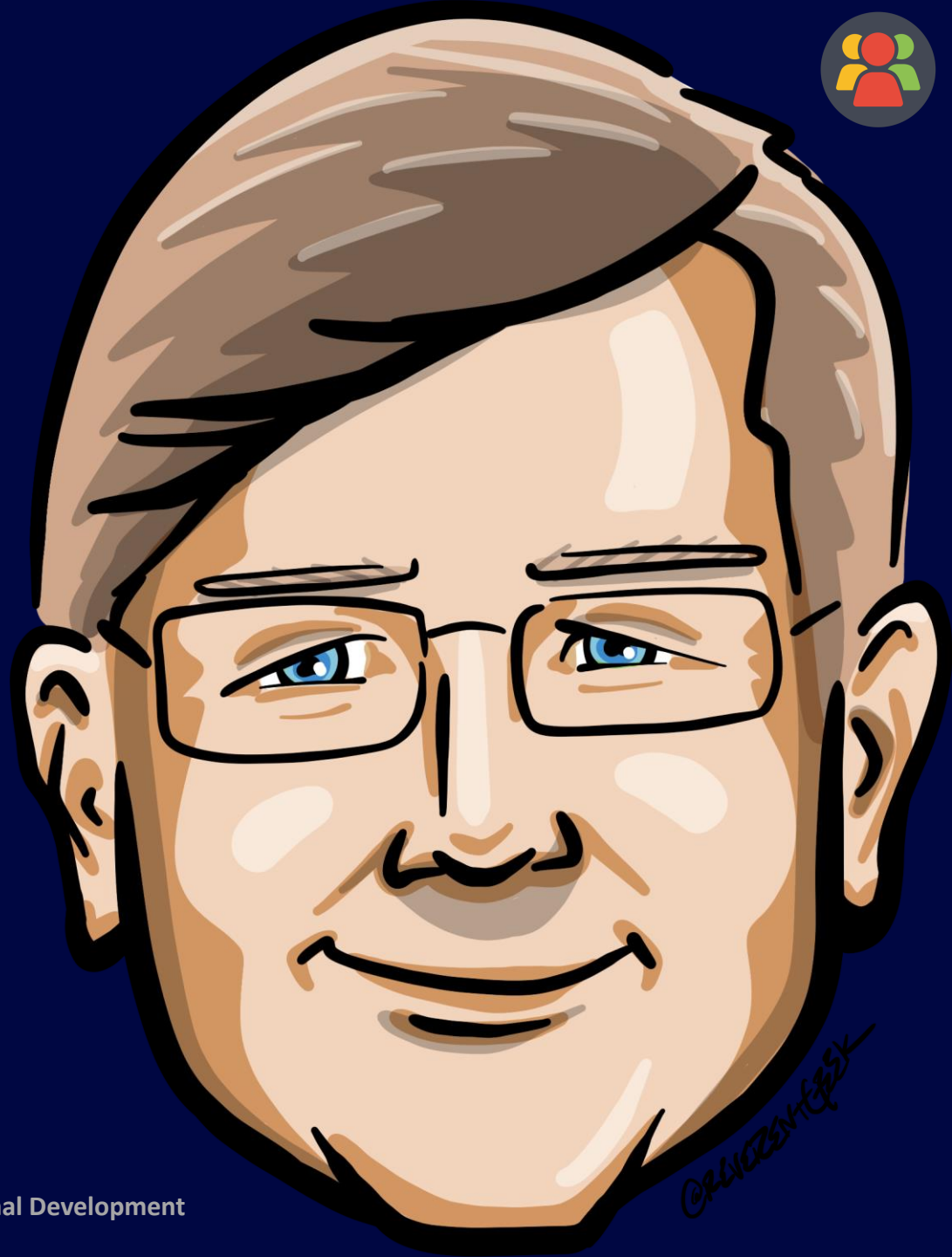

ESSENTIAL
SOFTWARE
DESIGN
PATTERNS

Who is Chad Green?



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What Are Design Patterns

Essential Software Design Patterns for Optimal Development

What Are Design Patterns

Essential Software Design Patterns for Optimal Development

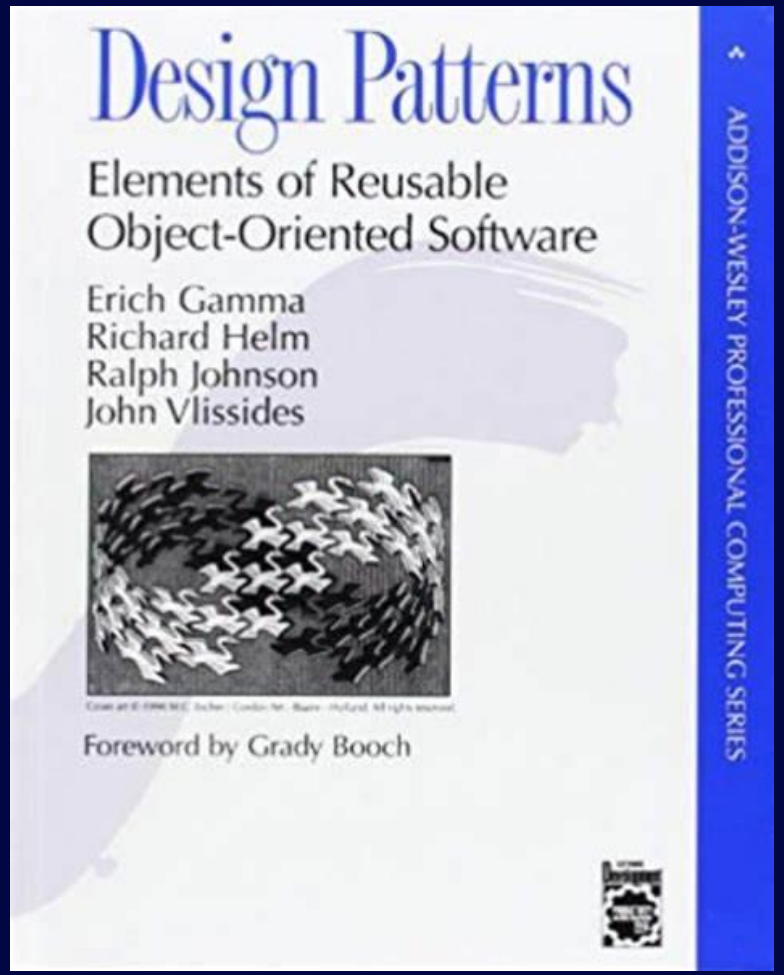
What Are Design Patterns

- Reusable solutions to common problems
- Best practices and proven solutions
- Building blocks for maintainable, scalable, and robust software

Why Design Patterns Matter

- Address complexity
- Encourage best practices and standardization
- Enhance code readability and maintainability
- Facilitate collaboration

Gang of Four


Design Patterns
Elements of Reusable
Object-Oriented Software
Erich Gamma
Richard Helm
Ralph Johnson
John Vlissides
Foreword by Grady Booch
ADDISON-WESLEY PROFESSIONAL COMPUTING SERIES

Types of Design Patterns

Creational

Structural

Behavioral

Creational Design Patterns

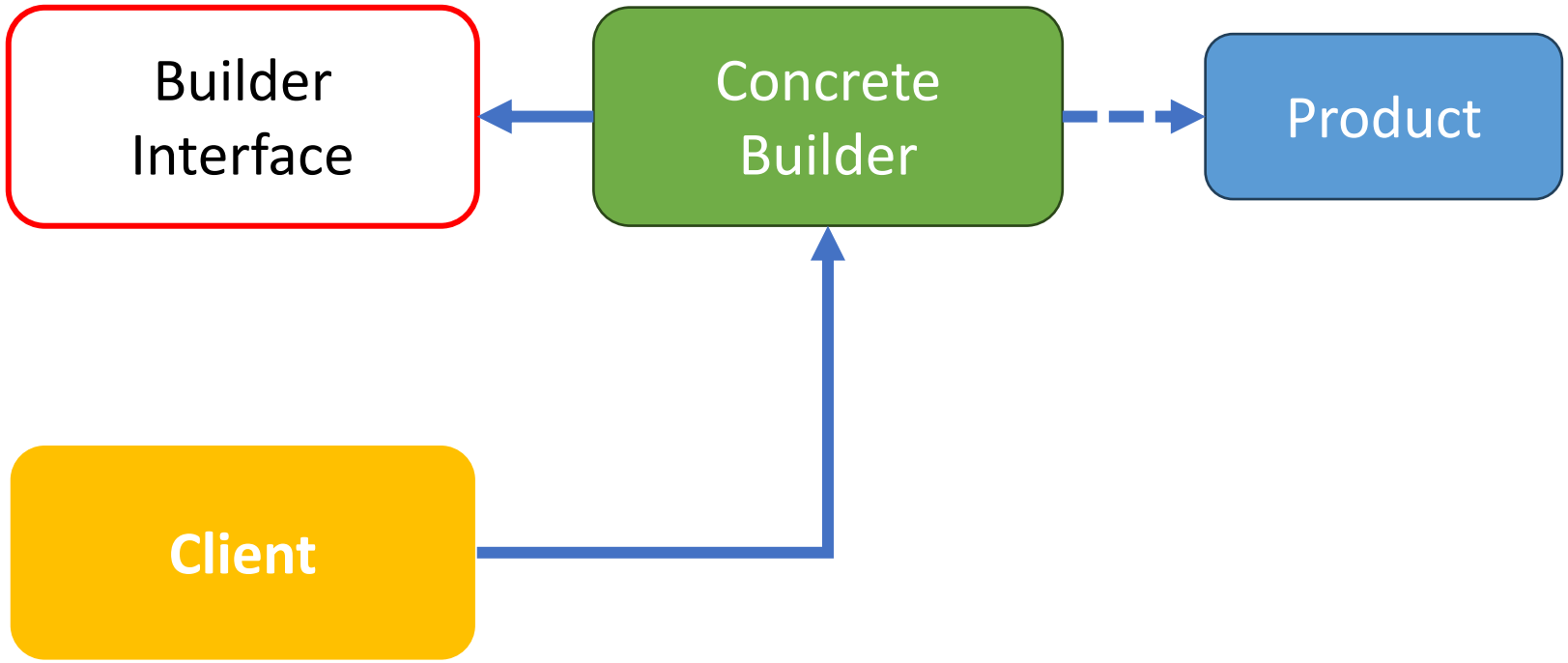
Essential Software Design Patterns for Optimal Development

Builder Pattern

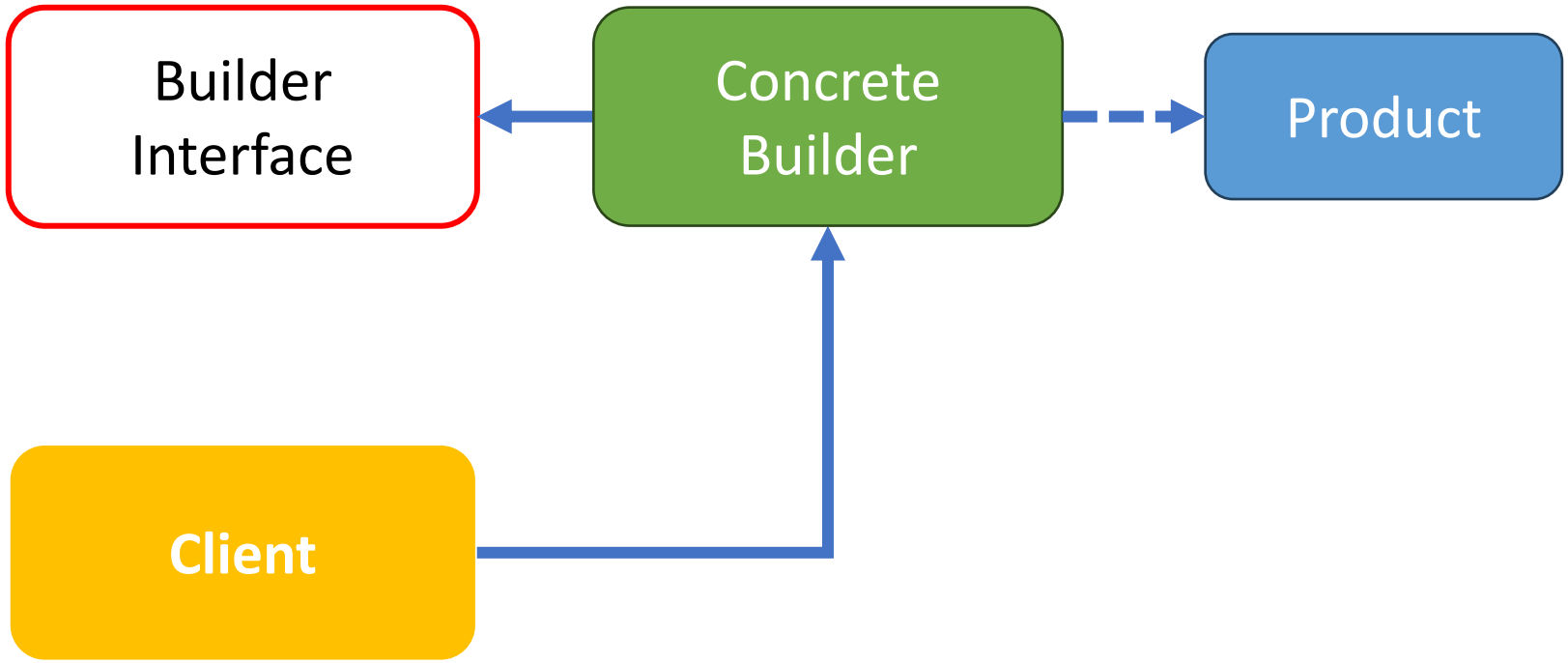
Creational Design Patterns

Builder Pattern

Builder Pattern



Builder Pattern



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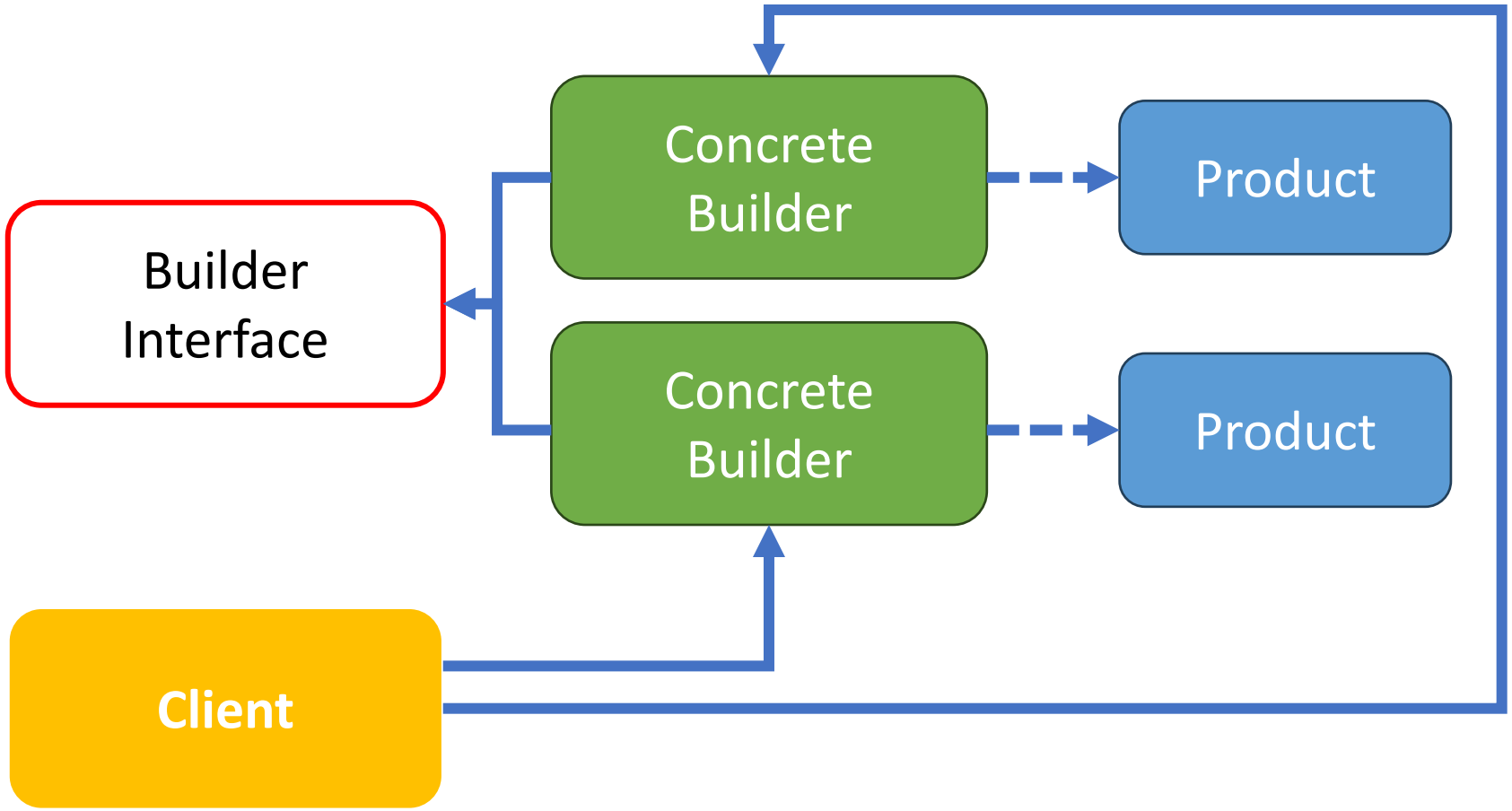

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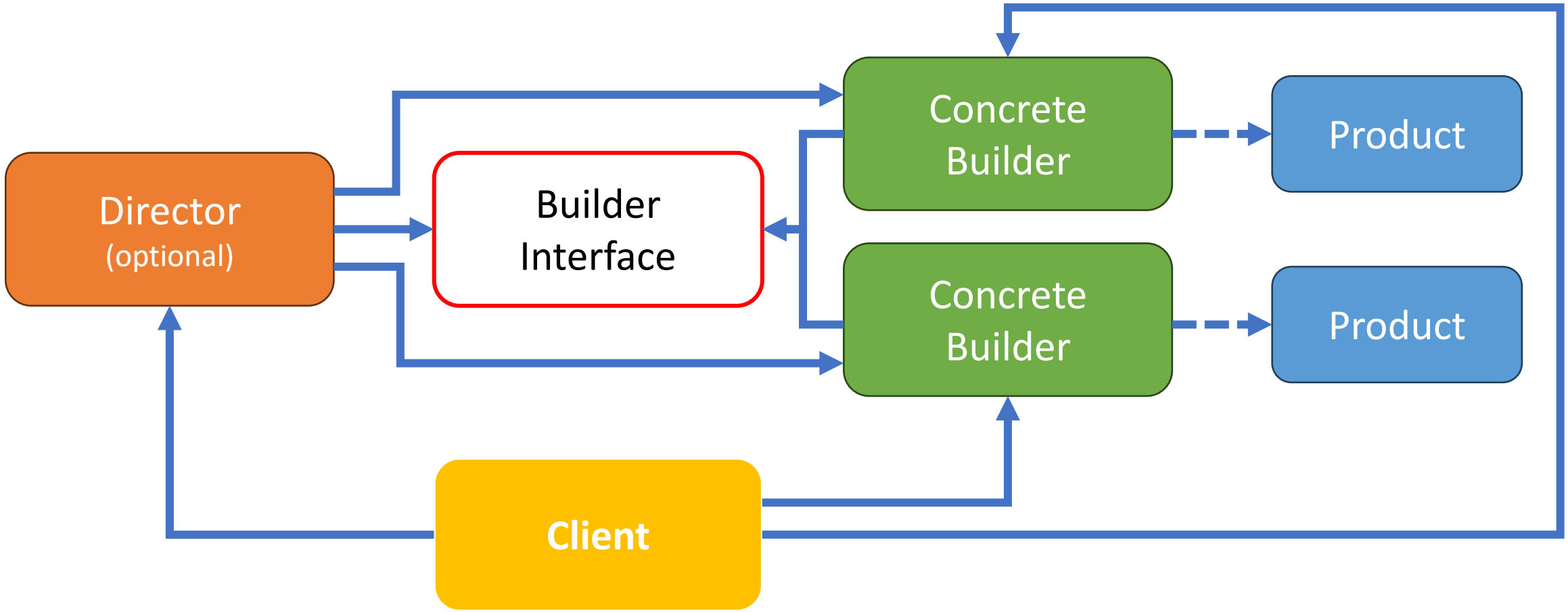

Builder - Product

```
public class Pizza
{
        public string Crust { get; set; }
        public string Sauce { get; set; }
        public List<string> Toppings { get; set; } = [];
}
```

Builder – Builder Interface

```
public interface IPizzaBuilder
{
        void BuildCrust();
        void BuildSauce();
        void BuildTopping();
        Pizza GetPizza();
}
```

Builder – Concrete Builder

```
public class HawaiianPizzaBuilder : IPizzaBuilder
{

    private readonly Pizza _pizza = new();

    public void BuildDough() => _pizza.Crust = "Original";

    public void BuildSauce() => _pizza.Sauce = "Classic Marinara";

    public void BuildTopping() => _pizza.Topping = ["Ham", "Pineapple"];

    public Pizza GetPizza() => _pizza;

}
```

Builder - Director

```
public class Waiter(IPizzaBuilder pizzaBuilder)
{
	private readonly IPizzaBuilder _pizzaBuilder = pizzaBuilder;

	public void ConstructPizza()
	{
		_pizzaBuilder.BuildDough();
		_pizzaBuilder.BuildSauce();
		_pizzaBuilder.BuildTopping();
	}

	public Pizza GetPizza() => _pizzaBuilder.GetPizza();

}
```

Builder - Client

```
IPizzaBuilder hawaiianPizzaBuilder = new HawaiianPizzaBuilder();
Waiter waiter = new(hawaiianPizzaBuilder);

waiter.ConstructPizza();
Pizza pizza = waiter.GetPizza();

Console.WriteLine($"Crust: {pizza.Crust}\nSauce: {pizza.Sauce}\nToppings:
      {string.Join(", ", pizza.Topping)}");
```

Builder Pattern

Benefits

- Separation of Concerns
- Encapsulation
- Reusability
- Complex Object Construction
- Control Over Construction Process
- Immutability

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Drawbacks

- Increased Complexity
- Boilerplate Code
- Potential Overhead
- Duplication of Code
- Limited Applicability
- Potential for Inconsistency

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• Separation of Concerns	• Increased Complexity
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Times to Use

- Complex Object Construction
- Variability in Object Representation
- Immutability and Thread Safety
- Creation of Composite Objects
- Testing

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Times When Not to Use

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- Static Configuration
- Limited Variability
- Highly Coupled Objects

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Factory Pattern

Creational Design Patterns

Abstract Product

```
public abstract class Animal
{
   public abstract void Speak();
}
```

Concrete Product

```
public class Dog : Animal
{
  public override void Speak() => Console.WriteLine("Dog says: Bow-Wow.");
}

public class Cat : Animal
{
  public override void Speak() => Console.WriteLine("Cat says: Meow.");
}
```

Concrete Factory

```
public static class AnimalFactory
{
  public static Animal CreateAnimal(AnimalType animalType)
    => animalType switch
    {
      AnimalType.Dog => new Dog(),
      AnimalType.Cat => new Cat(),
      _ => throw new ArgumentException("Invalid animal type."),
    };
}
```

Client Code

```
Animal dog = AnimalFactory.CreateAnimal(AnimalType.Dog);
dog.Speak();

Animal cat = AnimalFactory.CreateAnimal(AnimalType.Cat);
cat.Speak();
```

Factory Pattern

Benefits

- Encapsulation
- Loose Coupling
- Enhanced Code Maintainability
- Scalability and Flexibility
- Improved Testability
- Consistency in Object Creation

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- Overuse and Misuse
- Hidden Dependencies

Factory Pattern

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• Enhanced Code Maintainability	• Hidden Dependencies
• Scalability and Flexibility	
• Improved Testability	
• Consistency in Object Creation	

Factory Pattern

Times to Use

- Database Connection Management

```
DbConnection connection =
DbProviderFactory.GetFactory(database
Type).CreateConnection();
```

Factory Pattern

Times to Use

- Database Connection Management
- Logging Framework

```
ILogger logger =
LoggerFactory.CreateLogger(logType);
```

Factory Pattern

Times to Use

- Database Connection Management
- Logging Framework
- Parsing Different File Formats

```
IDocumentHandler handler =
DocumentHandlerFactory.CreateHandler(
documentType);
```

Factory Pattern

Times to Use

- Database Connection Management
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- Parsing Different File Formats
- Shape Creation

Factory Pattern

Times to Use

- Database Connection Management
- Logging Framework
- Parsing Different File Formats
- Payment Processing Systems
- Shape Creation
- Manufacturing

Times to Avoid

- Simple Object Creation
- Infrequent Changes to Object Creation Logic
- Static Configurations

Factory Pattern

Times to Use

- Database Connection Management
- Logging Framework
- Parsing Different File Formats
- Payment Processing Systems
- Shape Creation
- Manufacturing

Times to Avoid

- Simple Object Creation
- Performance-Critical Apps
- Infrequent Changes to Object Creation Logic
- Static Configurations

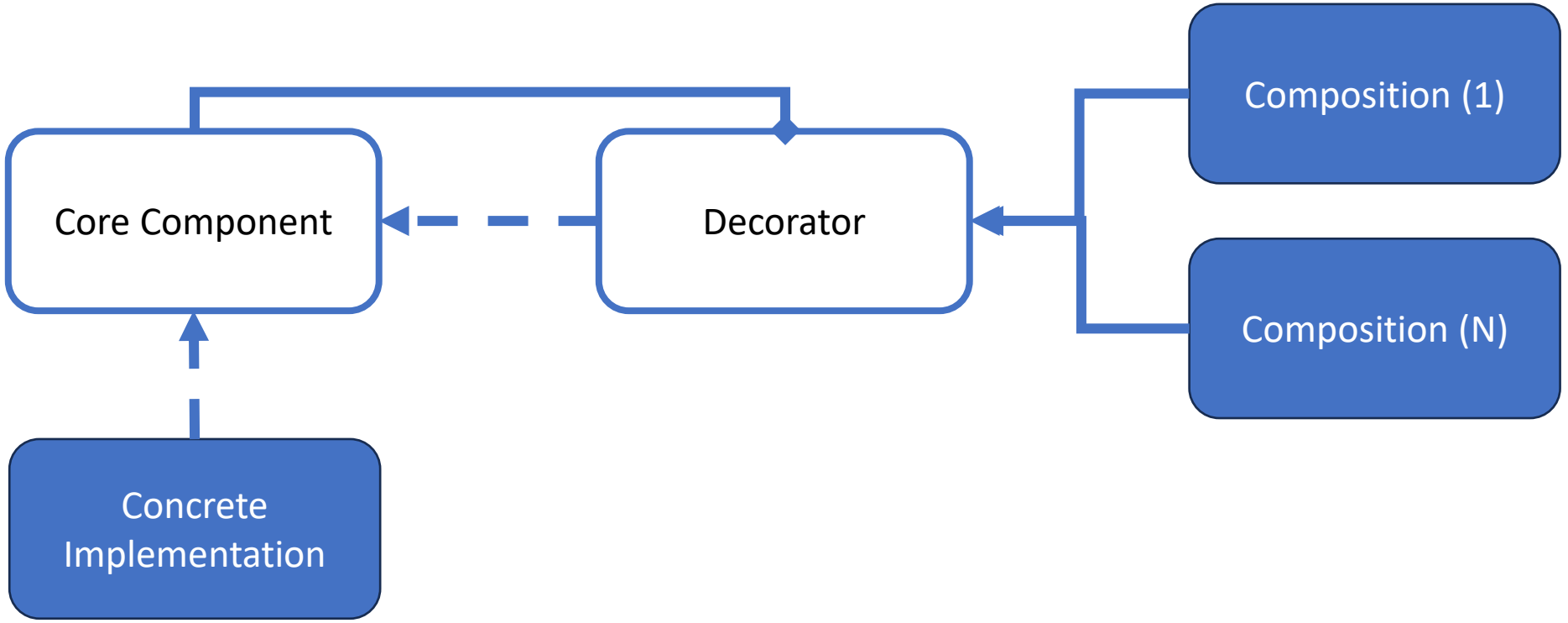
Structural Design Patterns

Essential Software Design Patterns for Optimal Development

Decorator Pattern

Structural Design Patterns

Decorator Pattern



Core Component

```
public interface ICar
{
  void Assemble();
}
```

Concrete Implementation

```
public interface ICar
{
  void Assemble();
}
```

```
public class BasicCar : ICar
{
  public void Assemble() => Console.WriteLine("Basic Car is assembled.");
}
```

Decorator

```
public interface ICar
{
  void Assemble();
}
```

```
public class CarDecorator(ICar car) : ICar
{
      protected ICar _car = car;

      public virtual void Assemble() => _car.Assemble();
}
```

Compositions

```
public class SportsCar(ICar car) : CarDecorator(car)
{
  public override void Assemble()
  {
    base.Assemble();
    Console.WriteLine("Adding features of Sports Car.");
  }
}
```

```
public class LuxuryCar(ICar car) : CarDecorator(car)
{
  public override void Assemble()
  {
    base.Assemble();
    Console.WriteLine("Adding features of Luxury Car.");
  }
}
```

Client

```
// Creating a basic car
ICar basicCar = new BasicCar();
basicCar.Assemble();

// Decorating basic car with sports car features
ICar sportsCar = new SportsCar(basicCar);
sportsCar.Assemble();

// Decorating basic car with luxury car features
ICar luxuryCar = new LuxuryCar(basicCar);
luxuryCar.Assemble();

// Decorating basic car with both sports and luxury car features
ICar sportsLuxuryCar = new LuxuryCar(new SportsCar(basicCar));
```

Client (More Performant)

```
// Creating a basic car
BasicCar basicCar = new();
basicCar.Assemble();

// Decorating basic car with sports car features
SportsCar sportsCar = new(basicCar);
sportsCar.Assemble();

// Decorating basic car with luxury car features
LuxuryCar luxuryCar = new(basicCar);
luxuryCar.Assemble();

// Decorating basic car with sports and luxury car features
LuxuryCar sportsLuxuryCar = new(new SportsCar(basicCar));
sportsLuxuryCar.Assemble();
```

Decorator Pattern

Benefits

- Enhanced Flexibility
- Open-Closed Principle
- Single Responsibility Principle
- Modular and Reusable Code
- Fine-Grained Control
- Transparent to Clients

Decorator Pattern

Benefits	Drawbacks
• Enhanced Flexibility	• Complexity
• Open-Closed Principle	• Potential of Object Proliferation
• Single Responsibility Principle	• Maintainability
• Modular and Reusable Code	• Ordering Dependencies
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Decorator Pattern

Good Times to Use

- Adding Functionality Dynamically
- Extending Functionality without Subclassing
- Open-Closed Principle Compliance
- Dynamic Configuration or Feature Selection

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Bad Times to Use

- Simple Functionality Addition
- Deeply Nested Decorated Chains
- Tightly Coupled Decorators
- Complex Ordering Dependencies

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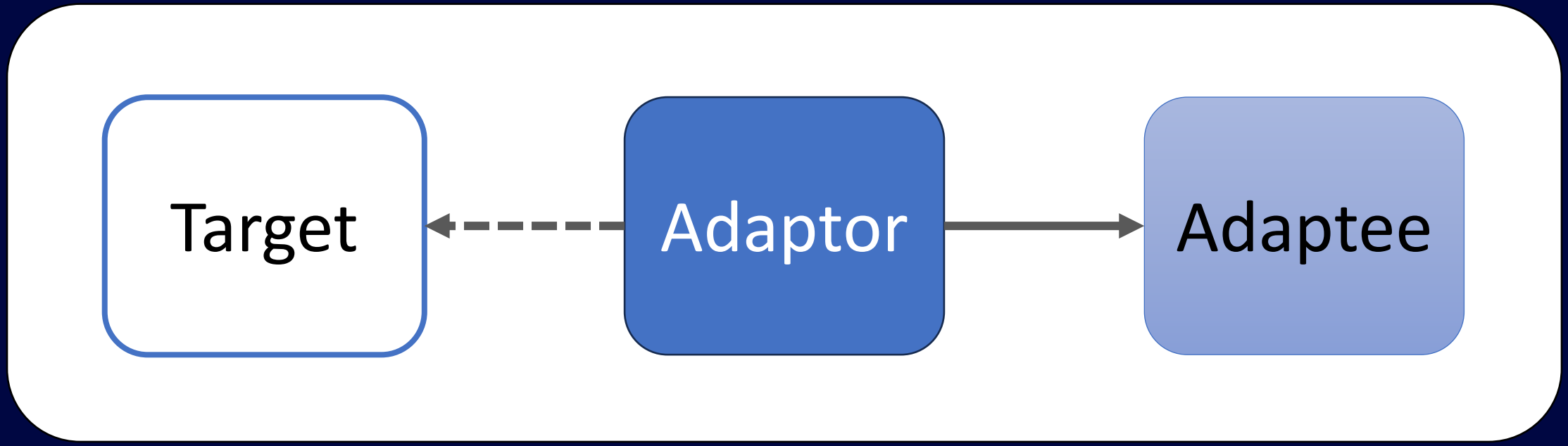
Adapter Pattern

Structural Design Patterns

Adapter Pattern Key Concepts



Adapter Pattern Types

Class Adapter

Object Adapter

Target Interface

```
public interface IMediaPlayer
{
   void Play(String audioType, String fileName);
}
```

Adaptee

```
public class LegacyAudioPlayer
{
  public void PlayMp3(String fileName)
    => Console.WriteLine("Playing mp3 file. Name: " + fileName);

  public void PlayWAV(String fileName)
    => Console.WriteLine("Playing WAV file. Name: " + fileName);
}
```

Adapter

```
public class MediaAdapter(LegacyAudioPlayer legacyAudioPlayer) : IMediaPlayer
{

  private readonly LegacyAudioPlayer _legacyAudioPlayer = legacyAudioPlayer;

  public void Play(string audioType, string fileName)
  {
    if (audioType.Equals("mp3", StringComparison.OrdinalIgnoreCase))
      _legacyAudioPlayer.PlayMp3(fileName);
    else if (audioType.Equals("wav", StringComparison.OrdinalIgnoreCase))
      _legacyAudioPlayer.PlayWAV(fileName);
    else
      Console.WriteLine("Invalid media. " + audioType + " format not supported");
  }

}
```

Client

```
IMediaPlayer player = new MediaAdapter(new LegacyAudioPlayer());
player.Play("mp3", "Thunderstuck.mp3");
player.Play("wav", "Back-In-Black.wav");
player.Play("flac", "Hells-Highway.flac"); // Unsupported format
```

Adapter Pattern

Benefits

- Interface Compatibility
- Reusability
- Flexibility
- Ease of Refactoring

Adapter Pattern

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Adapter Pattern

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- Using Third-Party Libraries
- Facilitating API Changes
- Bridging Different Technologies
- Abstracting Vendor-Specific Implementations

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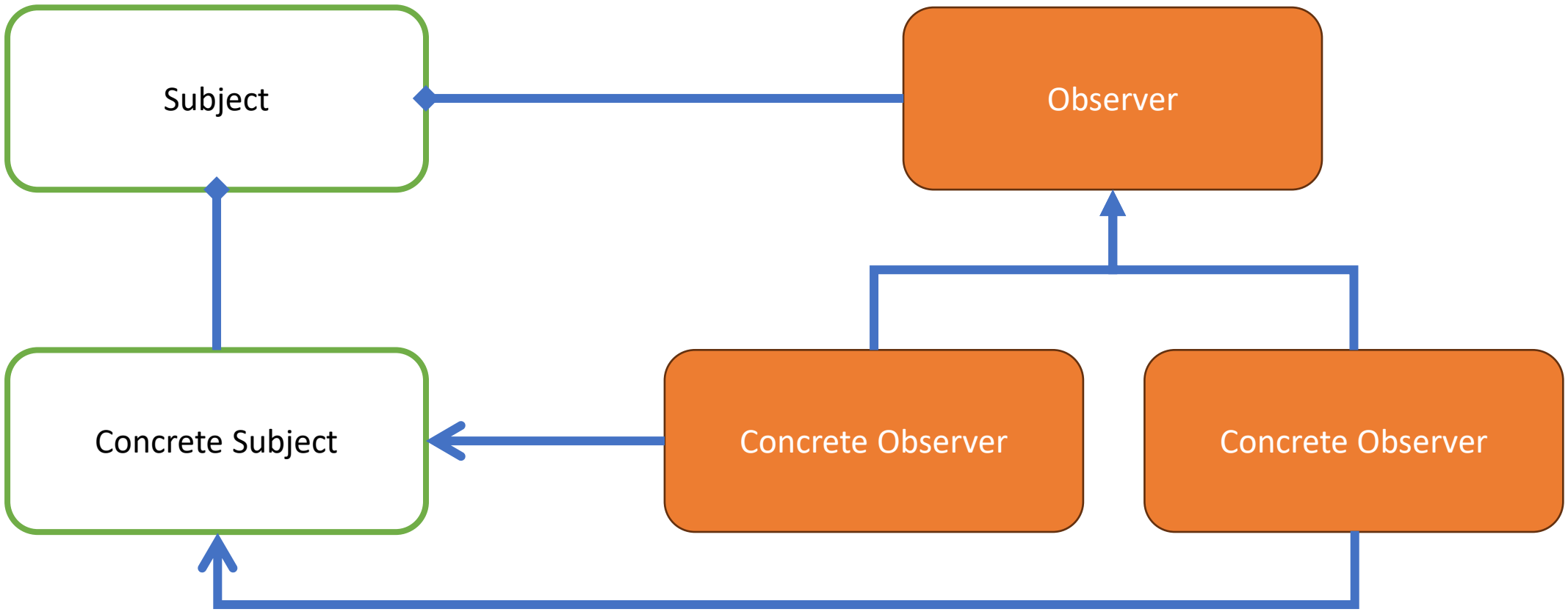
Behavioral Design Patterns

Essential Software Design Patterns for Optimal Development

Observer Pattern

Behavioral Design Patterns

Observer Pattern



Subject

```
public interface ISubject
{
  void Attach(IObserver observer);
  void Detach(IObserver observer);
  void Notify();
}
```

Observer

```
public interface IObserver
{
  void Update(ISubject subject);
}
```

Concrete Subject

```
public class ConcreteSubject : ISubject
{
  public int State { get; set; } = 0;

  private readonly List<IObserver> _observers = [];

  public void Attach(IObserver observer)
  {
    _observers.Add(observer);
  }

  public void Detach(IObserver observer)
  {
    _observers.Remove(observer);
  }

  public void Notify()
  {
    foreach (var observer in _observers)
      observer.Update(this);
  }
}
```

Concrete Observers

```
public class ConcreteObserverA : IObserver
{
  public void Update(ISubject subject)
  {
    if (subject is ConcreteSubject { State: < 3 })
    {
      Console.WriteLine("ConcreteObserverA: Reacted to the event.");
    }
  }
}
```

```
public class ConcreteObserverB : IObserver
{
  public void Update(ISubject subject)
  {
    if (subject is ConcreteSubject { State: 0 or >= 2 })
    {
      Console.WriteLine("ConcreteObserverB: Reacted to the event.");
    }
  }
}
```

Client

```
var subject = new ConcreteSubject();
var observerA = new ConcreteObserverA();
subject.Attach(observerA);

var observerB = new ConcreteObserverB();
subject.Attach(observerB);

subject.State = 0;
subject.Notify();

subject.State = 2;
subject.Notify();

subject.Detach(observerB);

subject.State = 3;
subject.Notify();
```

Observer Pattern

Benefits

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- Modular Design
- Event-Driven Architecture
- Support for Broadcast Communication
- Encapsulation
- Flexibility

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- Monitoring Systems
- Distributed Systems
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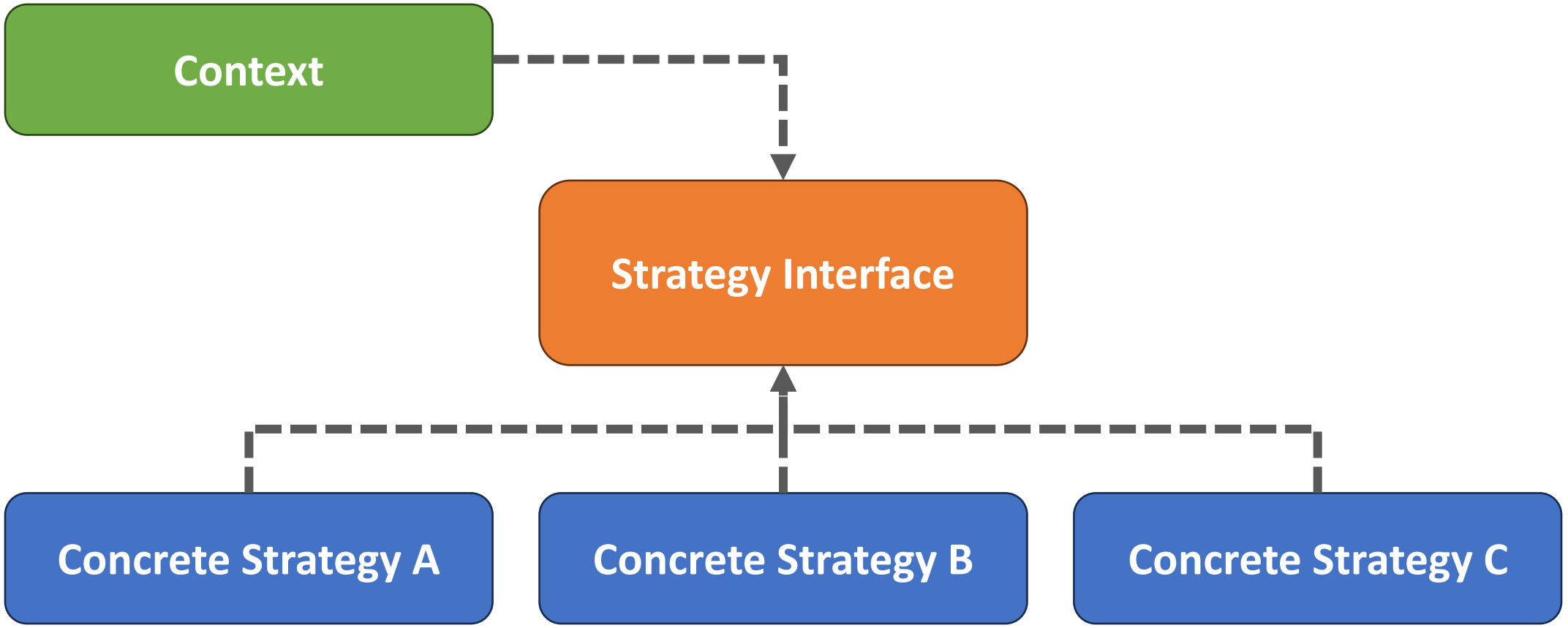
Strategy Pattern

Behavioral Design Patterns

Strategy Pattern



Strategy Interface

```
public interface IDiscountStrategy
{
  decimal ApplyDiscount(decimal price);
}
```

Concrete Strategies

```
public class NoDiscount : IDiscountStrategy
{
  public decimal ApplyDiscount(decimal price) => price; // No discount applied
}

public class SeasonalDiscount : IDiscountStrategy
{
  public decimal ApplyDiscount(decimal price) => price * 0.9m; // 10% discount
}

public class LoyaltyDiscount : IDiscountStrategy
{
  public decimal ApplyDiscount(decimal price) => price * 0.85m; // 15% discount
}
```

Context

```
public class PriceCalculator(IDiscountStrategy discountStrategy)
{

  private IDiscountStrategy _discountStrategy = discountStrategy;

  public void SetDiscountStrategy(IDiscountStrategy discountStrategy)
    => _discountStrategy = discountStrategy;

  public decimal CalculatePrice(decimal price)
    => _discountStrategy.ApplyDiscount(price);

}
```

Implementation

```
decimal originalPrice = 100.0m;

PriceCalculator calculator = new PriceCalculator(new NoDiscount());
decimal noDiscountPrice = calculator.CalculatePrice(originalPrice);
Console.WriteLine($"Original Price: {originalPrice}, Price with No Discount:
{noDiscountPrice}");

calculator.SetDiscountStrategy(new SeasonalDiscount());
decimal seasonalDiscountPrice = calculator.CalculatePrice(originalPrice);
Console.WriteLine($"Original Price: {originalPrice}, Price with Seasonal Discount:
{seasonalDiscountPrice}");

calculator.SetDiscountStrategy(new LoyaltyDiscount());
decimal loyaltyDiscountPrice = calculator.CalculatePrice(originalPrice);
Console.WriteLine($"Original Price: {originalPrice}, Price with Loyalty Discount:
{loyaltyDiscountPrice}");
```

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- Maintainability
- Ease of Extension
- Simplified Testing and Debugging
- Runtime Flexibility

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- Client Awareness

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- Payment Processing Systems
- File Compression
- Authentication Mechanisms
- Log Formatting

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Careful Consideration Needed

Essential Software Design Patterns for Optimal Developer

Pattern Considerations

- Should be applied judiciously

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- Appropriateness influenced by nature of software being developed

Pattern Considerations

- Should be applied judiciously
- Appropriateness influenced by nature of software being developed
- Essential to carefully evaluate trade-offs

Other Categories of Design Patterns

Essential Software Development Patterns for Optimal Development

Design Pattern Categories

Creational

Structural

Behavioral

Design Pattern Categories

Creational

Structural

Behavioral

Concurrency

- Thread Pool
- Producer-Consumer
- Reader-Writers

Types of Design Patterns

Creational

Structural

Behavioral

Concurrency

- Event-Driven Architecture
- Layered Architecture
- Microservices

Architectural

- Model-View-Controller (MVC)
- Service-Oriented Architecture

Types of Design Patterns

Creational

Structural

Behavioral

Concurrency

Architectural

Cloud

- Simple Web Service
- Robust API
- Decoupled Messaging
- Publish/Subscribe

- Aggregation
- Strangler
- Queue-Based Load Leveling
- Pipes and Filters

- Fan-Out/Fan-In
- Materialized Views

Summary

Essential Software Design Patterns

Summary

- Overview of Design Patterns
- Builder Pattern (Creational)
- Factory Pattern (Creational)
- Decorator Pattern (Structural)
- Adapter Pattern (Structural)
- Observer Pattern (Behavioral)
- Strategy Pattern (Behavioral)
- Considerations
- Other Categories of Design Patterns

Thank You

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