

ESSENTIAL SOFTWARE DESIGN PATTERNS



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Who is Chad Green?

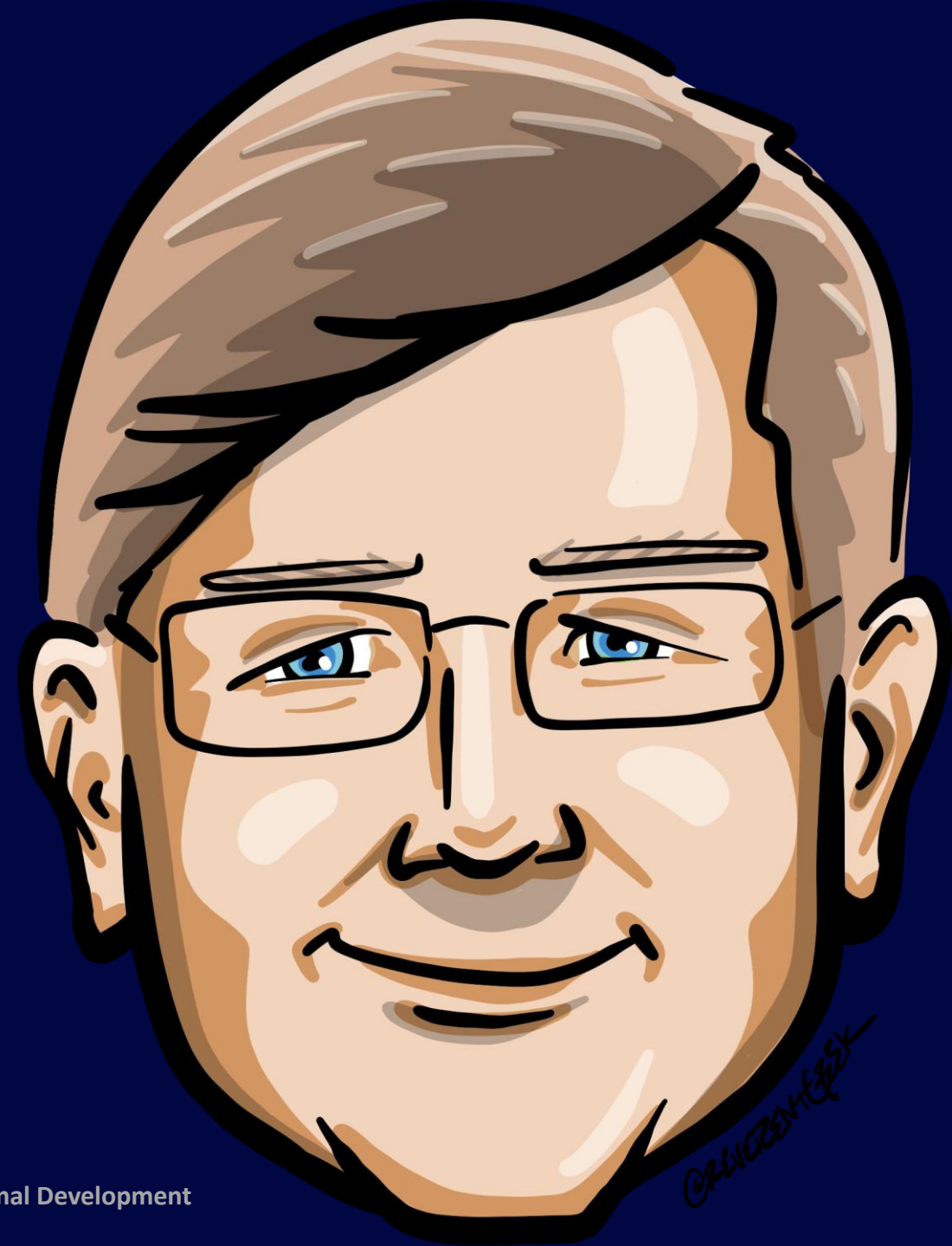
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What Are Design Patterns

Essential Software Design Patterns for Optimal Development

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Essential Software Design Patterns for Optimal Development

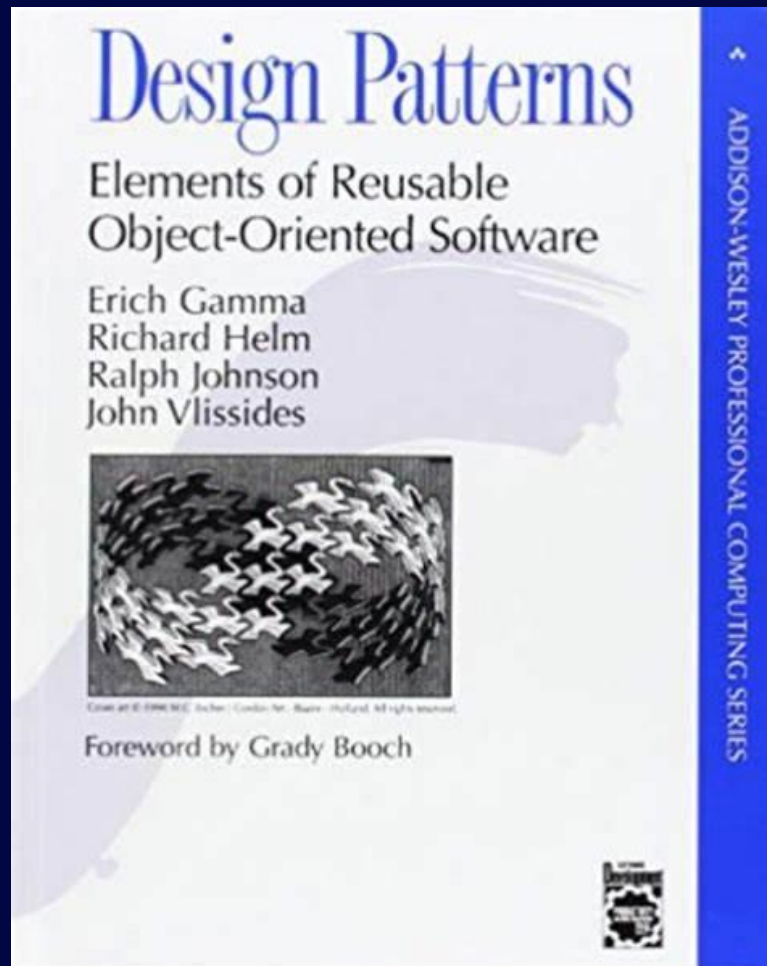
What Are Design Patterns

- 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



Types of Design Patterns

Creational

Structural

Behavioral

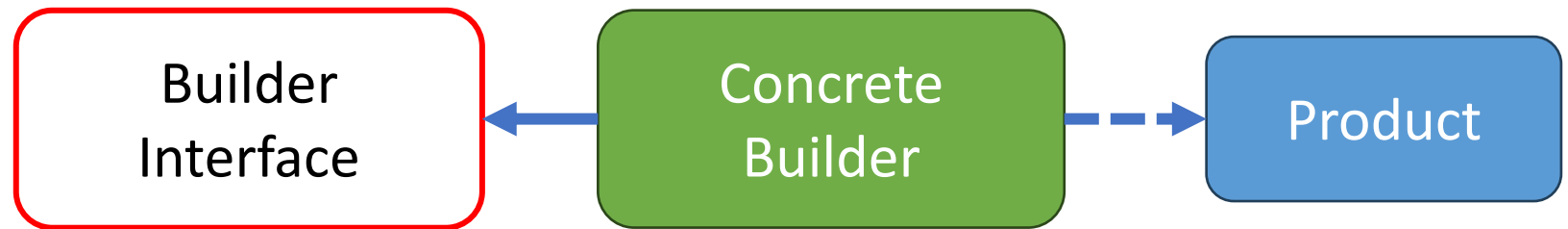
Creational Design Patterns

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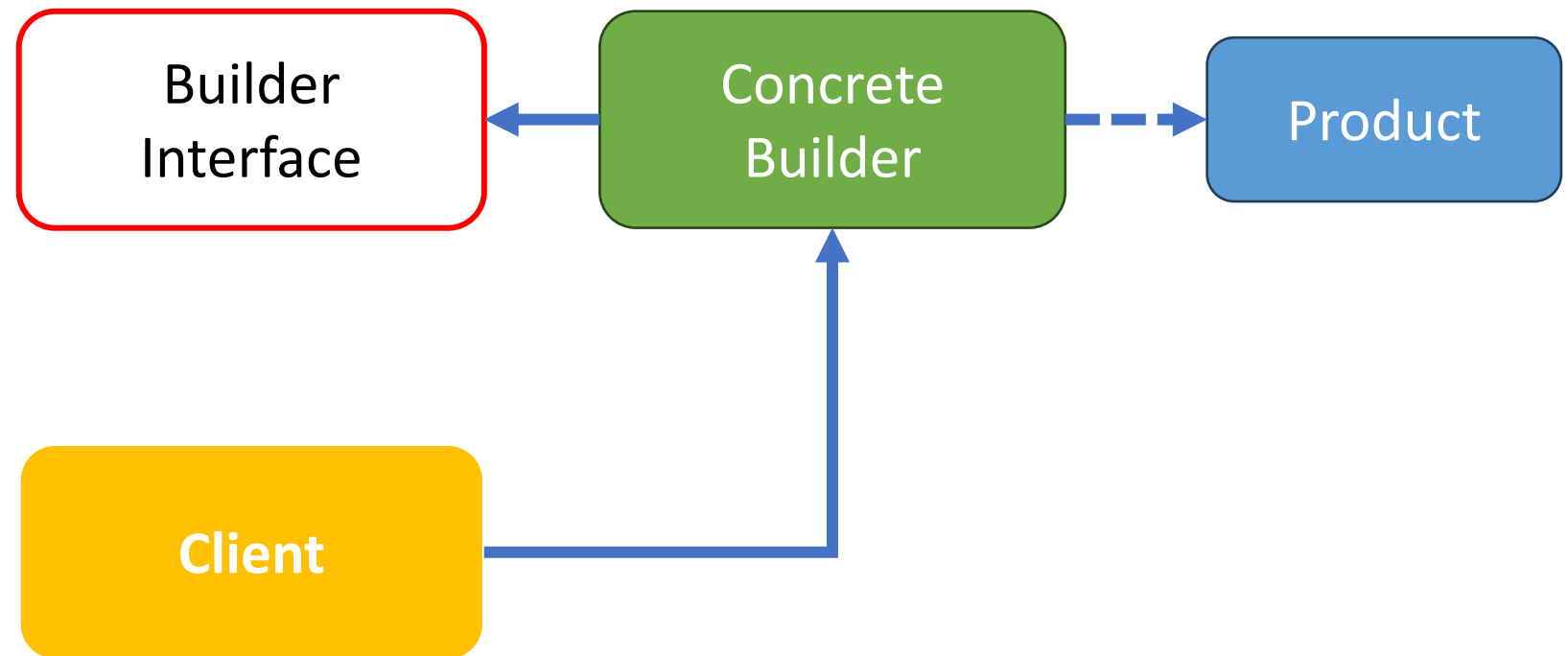
Builder Pattern

Creational Design Patterns

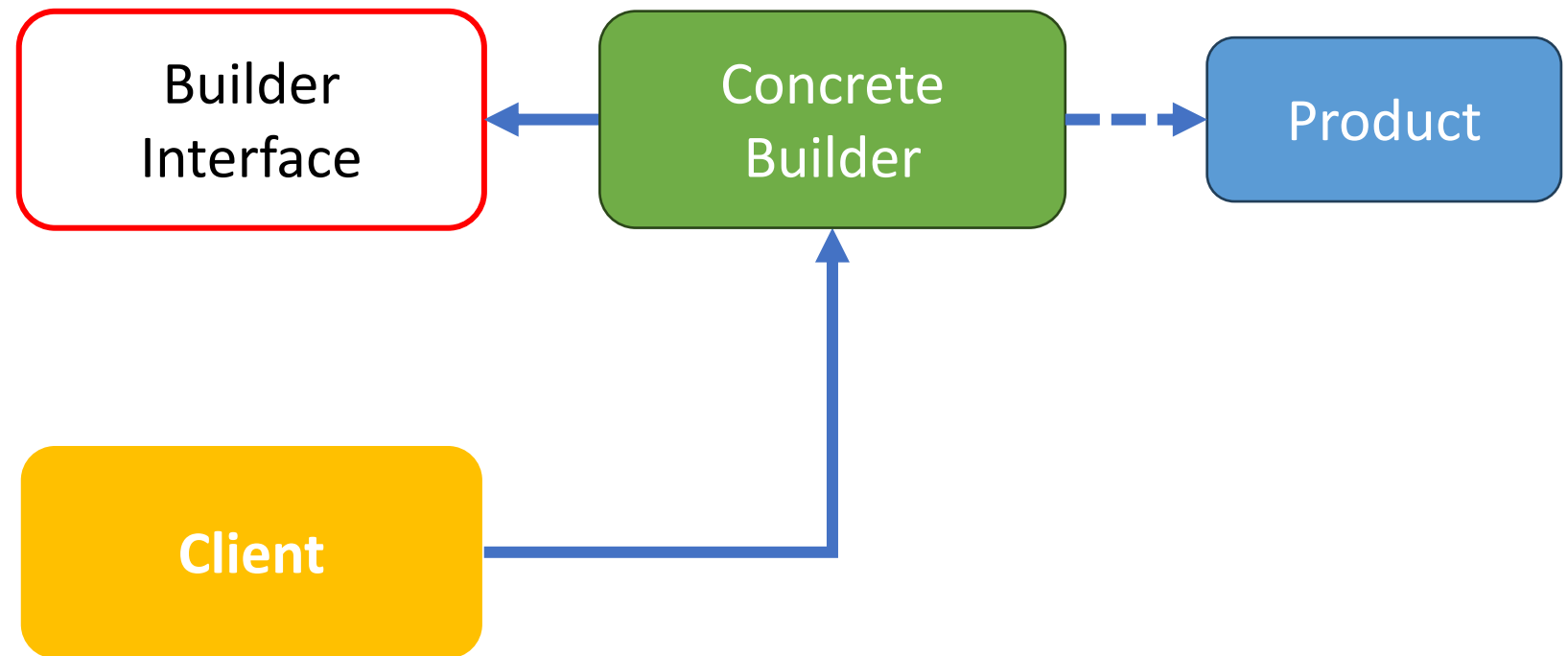
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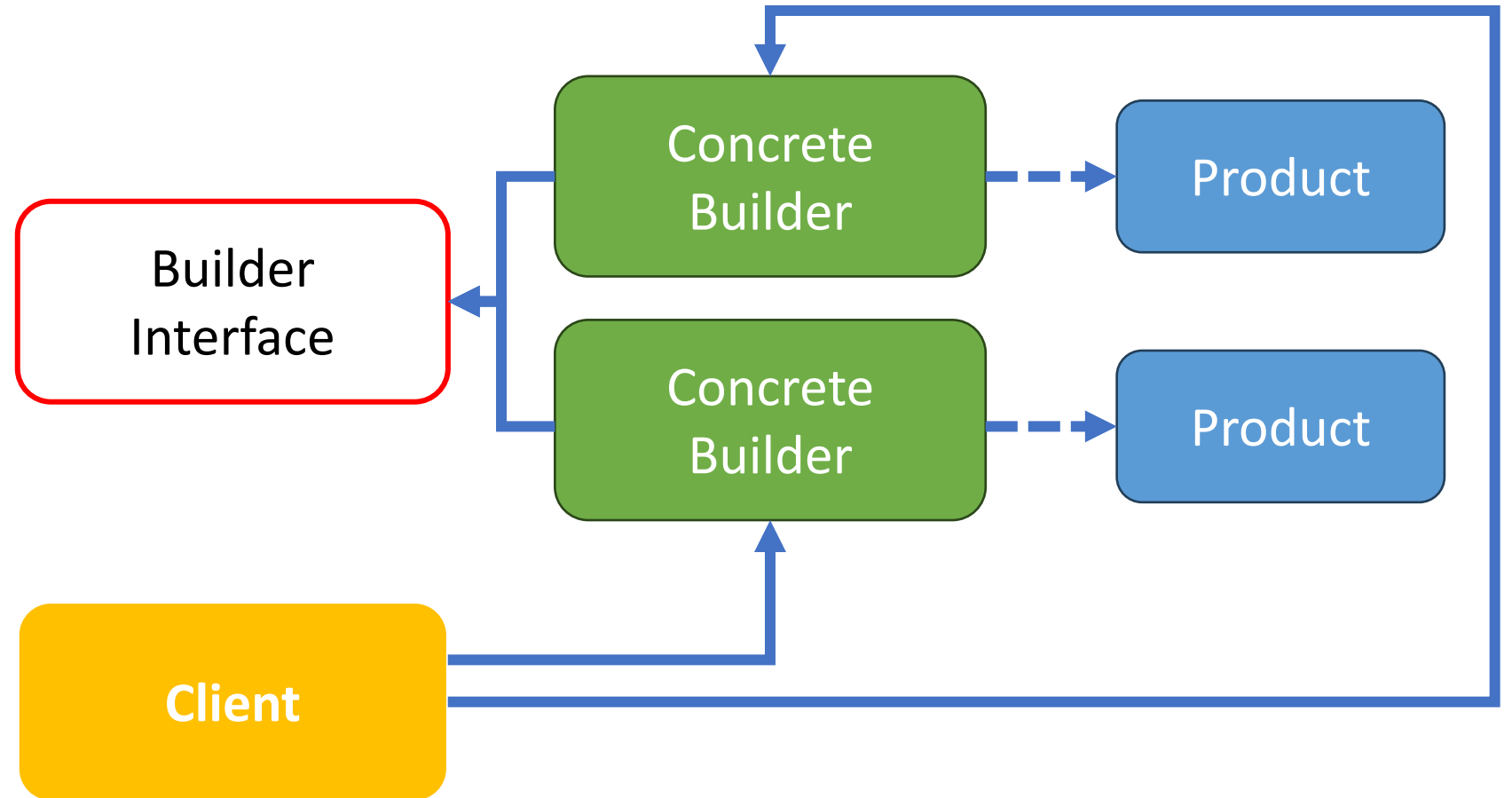
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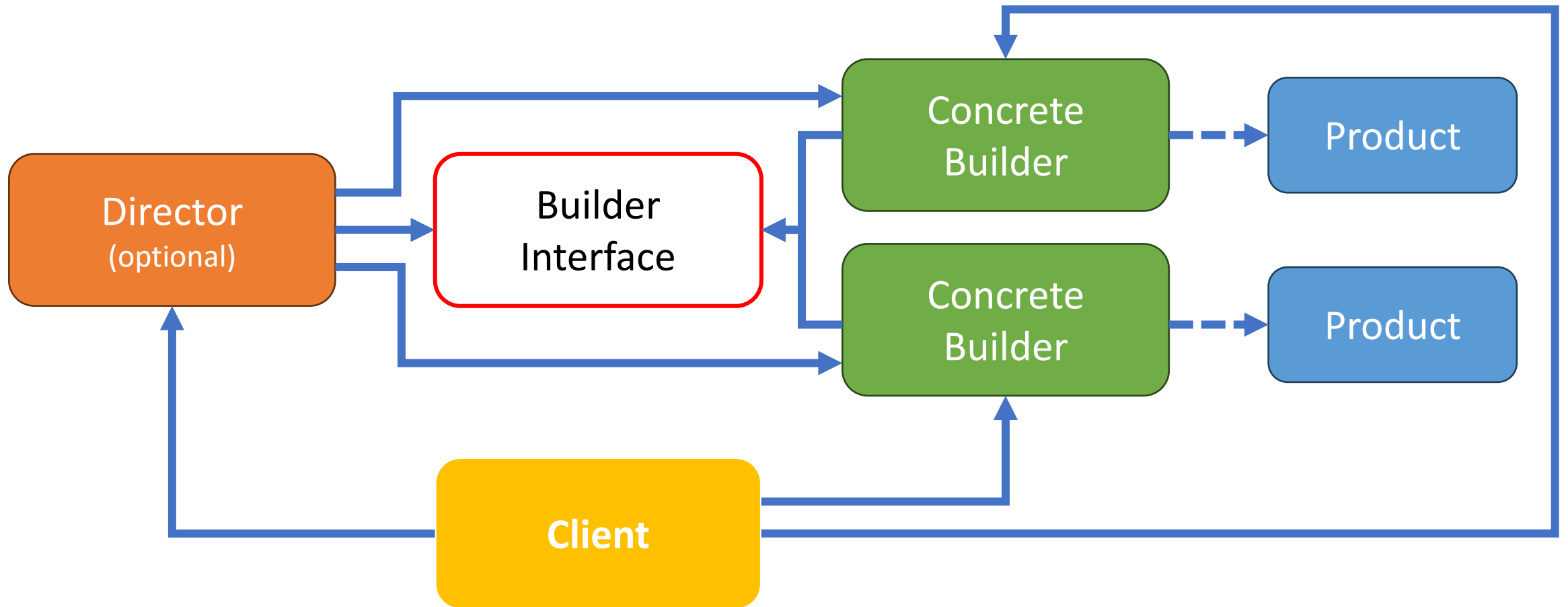
Builder Pattern



Builder Pattern



Builder Pattern



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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- Potential Overhead
- Duplication of Code
- Limited Applicability
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Times to Use

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

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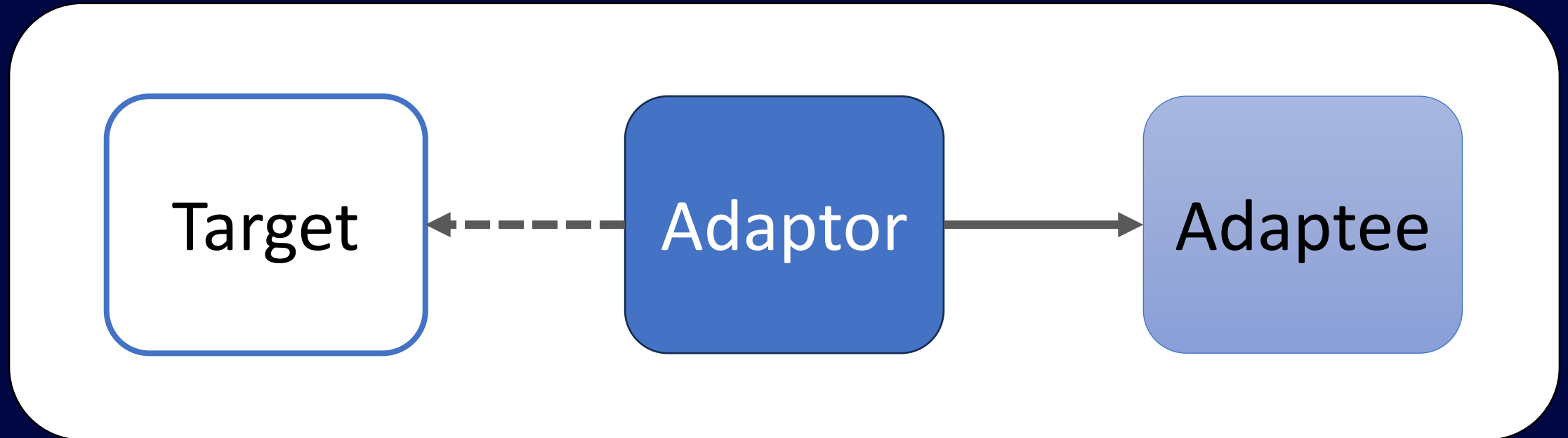
Structural Design Patterns

Essential Software Design Patterns for Optimal Development

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

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- Interface Compatibility
- Reusability
- Flexibility
- Ease of Refactoring

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- Using Third-Party Libraries
- Facilitating API Changes
- Bridging Different Technologies
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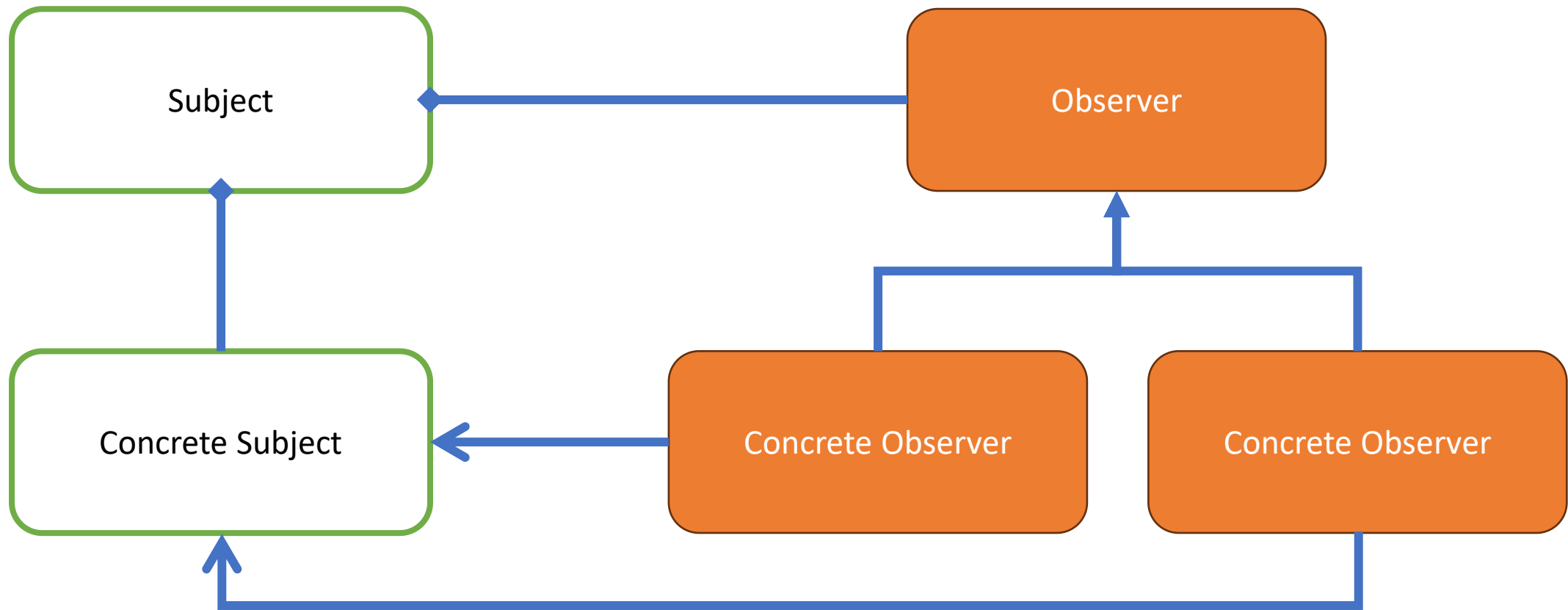
Behavioral Design Patterns

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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

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- Modular Design
- Event-Driven Architecture
- Support for Broadcast Communication
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- Monitoring Systems
- Distributed Systems
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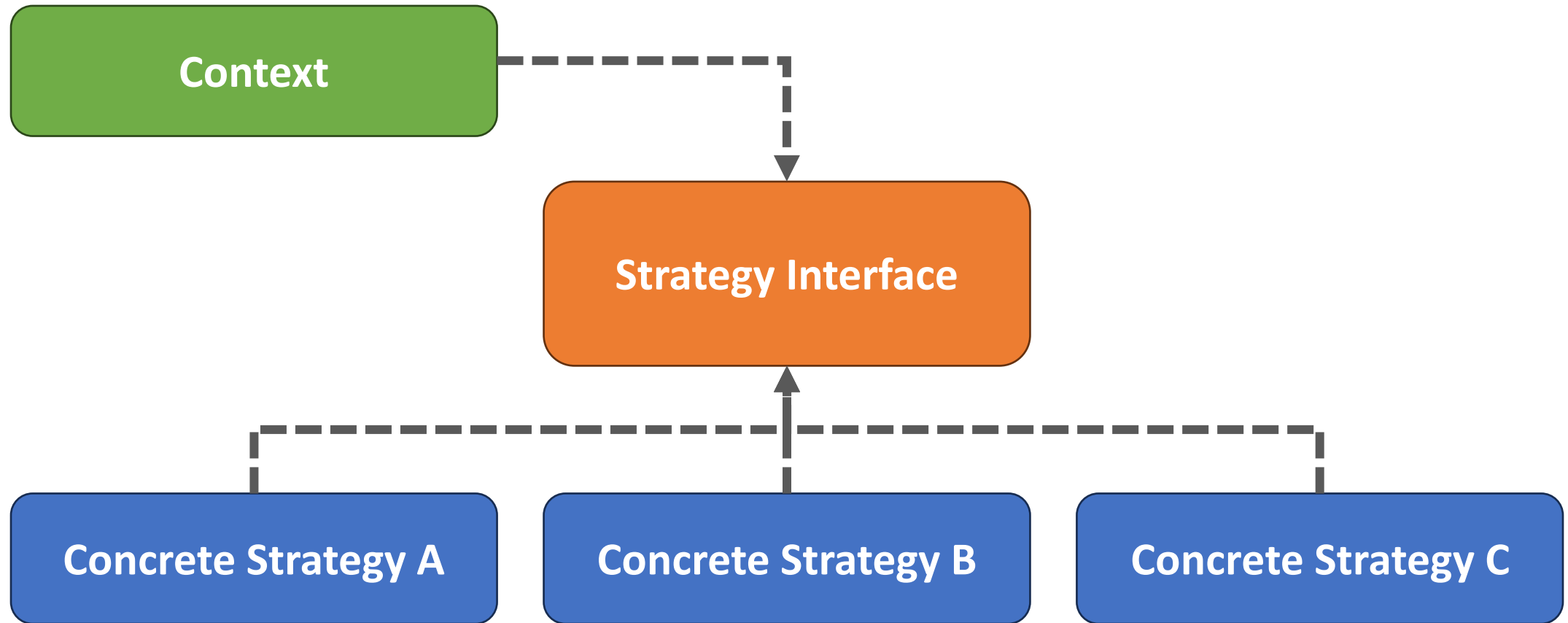
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Strategy Pattern

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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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

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- 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

Architectural

- Event-Driven Architecture
- Layered Architecture
- Microservices

- 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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