REEVALUATING SOFTWARE DESIGN PATTERNS

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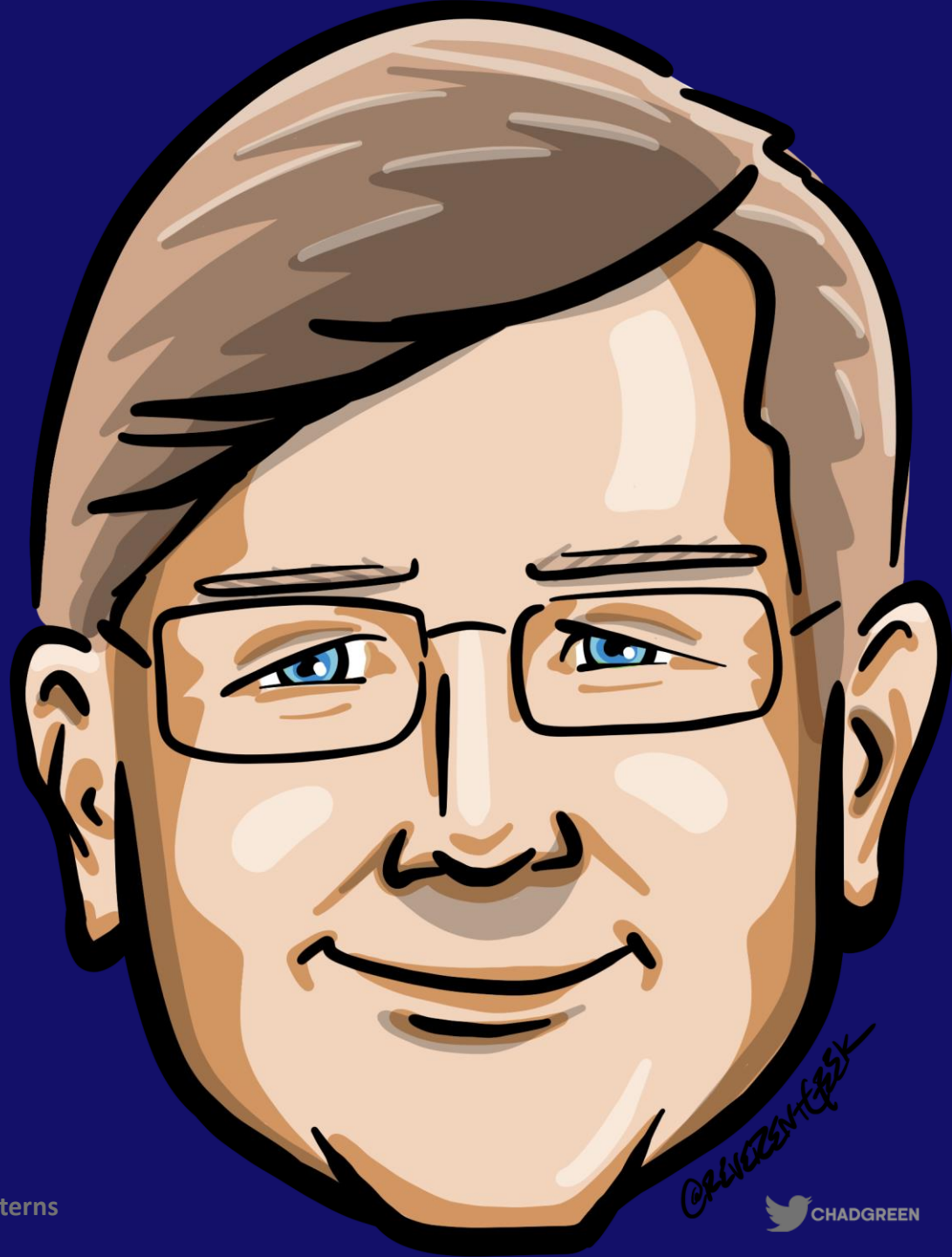


The Power of Design Patterns

Reevaluating Software Design Patterns

Significance of Design Patterns

Code Reusability

Significance of Design Patterns

Code Reusability

Scalability and Maintainability

Significance of Design Patterns

Code Reusability

Scalability and Maintainability

Common Vocabulary

Significance of Design Patterns

- Code Reusability
- Scalability and Maintainability
- Common Vocabulary
- **Best Practices**

Significance of Design Patterns

Code Reusability

Scalability and Maintainability

Common Vocabulary

Best Practices

Abstraction and Flexibility

Significance of Design Patterns

- Code Reusability
- Scalability and Maintainability
- Common Vocabulary
- Best Practices
- Abstraction and Flexibility
- **Ease of Maintenance**

Significance of Design Patterns

- Code Reusability
- Scalability and Maintainability
- Common Vocabulary
- Best Practices
- Abstraction and Flexibility
- Ease of Maintenance
- **Learning and Onboarding**

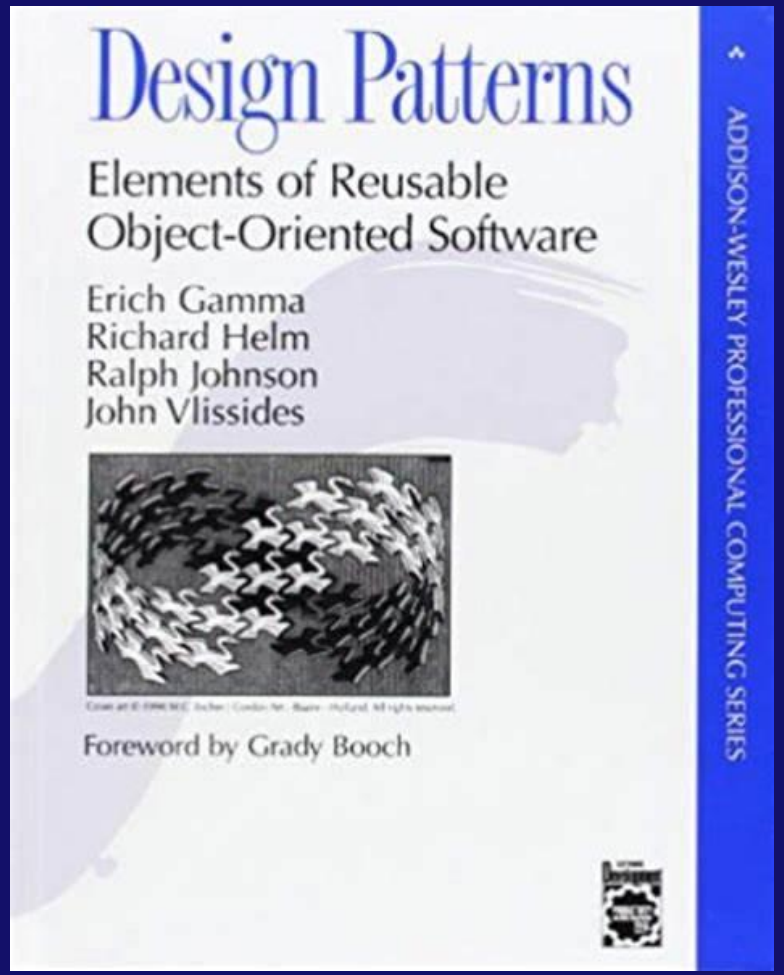
Significance of Design Patterns

- Code Reusability
- Scalability and Maintainability
- Common Vocabulary
- Best Practices
- Abstraction and Flexibility
- Ease of Maintenance
- Learning and Onboarding
- **Documentation**

Significance of Design Patterns

- Code Reusability
- Scalability and Maintainability
- Common Vocabulary
- Best Practices
- Abstraction and Flexibility
- Ease of Maintenance
- Learning and Onboarding
- Documentation

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

Main Types of Design Patterns

Creation

- Interpreter
- Template Method
- Chain of Responsibility
- Command
- Iterator
- Mediator
- Memento
- Observer
- State
- Strategy
- Visitor

Main Types of Design Patterns

Creation

- Factory Method
- Abstract Factory
- Builder

Structural

- Prototype
- Singleton

Main Types of Design Patterns

Creation

Structural

Behavioral

- Adapter
- Bridge
- Composite
- Decorator

- Façade
- Flyweight
- Proxy

Main Types of Design Patterns

Creation

Structural

Behavioral

Architectural

- Model-View-Controller (MVC)
- Layered Architecture
- Microservices
- Event-Driven Architecture
- Service-Oriented Architecture

Not All Patterns Are Created Equal

Reevaluating Software Design Patterns

Not all patterns are created equal

- Should be applied judiciously

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- **Appropriateness influenced by nature of software being developed**

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

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- Essential to carefully evaluate trade-offs

The Problematic Patterns

Reevaluating Software Design Patterns

Not talking about anti-patterns

- God Object
- Spaghetti Code
- Copy-Paste Programming
- Magic Numbers
- Hard Coding
- Lava Flow
- Circular Dependency
- Premature Optimization

The Problematic Patterns

- Singleton
- Observer
- Factory
- Abstract Factory
- Template Method
- Microservices

Singleton Pattern

Reevaluating Software Design Patterns

Singleton Pattern

Single Instance

Singleton Pattern

Single Instance

Global Access

Singleton Pattern

Single Instance

Global Access

Lazy Initialization

Singleton Pattern

Single Instance

Global Access

Lazy Initialization

Private Constructor

Singleton Pattern

Single Instance

Global Access

Lazy Initialization

Private Constructor

Static Instance Method/Property

Demo: Singleton Pattern

Singleton Class

```
public class Logger
{
  private static Logger? instance;

  // Additional properties or methods can be added here

  // Private constructor to prevent instantiation
  private Logger() { }

  // Lazy initialization, create instance only if needed
  public static Logger GetInstance()
  {
    instance ??= new Logger();
    return instance;
  }

  public void LogMessage(string message) => Console.WriteLine($"Logging: {message}");

}
```

Singleton Class

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  // Lazy initialization, create instance only if needed
  public static Logger GetInstance()
  {
    instance ??= new Logger();
    return instance;
  }

  public void LogMessage(string message) => Console.WriteLine($"Logging: {message}");

}
```

Main Object

```
// Using the Singleton Logger
Logger logger = Logger.GetInstance();
logger.LogMessage("Application started");

// Using the Singleton Logger within a service
UserService userService = new();
userService.PerformUserAction("JohnDoe", "Login");

// Ensure that the same logger instance is used throughout the application
Logger anotherLogger = Logger.GetInstance();
Console.WriteLine($“Same instance? {ReferenceEquals(logger, anotherLogger)}");
```

Main Object

```
// Using the Singleton Logger
Logger logger = Logger.GetInstance();
logger.LogMessage("Application started");
```

```
// Using the Singleton Logger within a service
UserService userService = new();
userService.PerformUserAction("JohnDoe", "Login");

// Ensure that the same logger instance is used throughout the application
Logger anotherLogger = Logger.GetInstance();
Console.WriteLine($"Same instance? {ReferenceEquals(logger, anotherLogger)}");
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Main Object

```
// Using the Singleton Logger
Logger logger = Logger.GetInstance();
logger.LogMessage("Application started");
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```
// Using the Singleton Logger within a service
UserService userService = new();
userService.PerformUserAction("JohnDoe", "Login");
```

```
// Ensure that the same logger instance is used throughout the application
Logger anotherLogger = Logger.GetInstance();
Console.WriteLine($"Same instance? {ReferenceEquals(logger, anotherLogger)}");
```

Another Object

```
public class UserService
{
  private readonly Logger logger;

  public UserService()
  {
    logger = Logger.GetInstance();
  }

  public void PerformUserAction(string userName, string action)
  {
    // Some business logic
    logger.LogMessage($"User '{userName}' performed action: {action}");
  }
}
```

Main Object

```
// Using the Singleton Logger
Logger logger = Logger.GetInstance();
logger.LogMessage("Application started");

// Using the Singleton Logger within a service
UserService userService = new();
userService.PerformUserAction("JohnDoe", "Login");
```

```
// Ensure that the same logger instance is used throughout the application
Logger anotherLogger = Logger.GetInstance();
Console.WriteLine($“Same instance? {ReferenceEquals(logger, anotherLogger)}");
```

Singleton Pattern: The Good

Centralized Logging

Singleton Pattern: The Good

Centralized Logging

Global Access to Logger

Singleton Pattern: The Good

Centralized Logging

Global Access to Logger

Lazy Initialization

Singleton Pattern: The Good

Centralized Logging

Global Access to Logger

Lazy Initialization

Instance Reusability

Singleton Pattern: The Good

- Centralized Logging
- Global Access to Logger
- Lazy Initialization
- Instance Reusability
- Straightforward Usage

Singleton Pattern: The Good

- Centralized Logging
- Global Access to Logger
- Lazy Initialization
- Instance Reusability
- Straightforward Usage
- Simple Initialization

Singleton Pattern: The Good

- Centralized Logging
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Singleton Pattern: The Bad

Global State

Singleton Pattern: The Bad

Global State

Tight Coupling

Singleton Pattern: The Bad

- Global State
- Tight Coupling
- Testing Challenges

Singleton Pattern: The Bad

- Global State
- Tight Coupling
- Testing Challenges
- Hidden Dependencies

Singleton Pattern: The Bad

- Global State
- Tight Coupling
- Testing Challenges
- Hidden Dependencies
- Inflexible Initialization

Singleton Pattern: The Bad

- Global State
- Tight Coupling
- Testing Challenges
- Hidden Dependencies
- Inflexible Initialization
- Thread Safety Issues

Singleton Pattern: The Bad

Global State

Tight Coupling

Testing Challenges

Hidden Dependencies

Inflexible Initialization

Thread Safety Issues

- Race Conditions

Singleton Pattern: The Bad

Global State

Tight Coupling

Testing Challenges

Hidden Dependencies

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Thread Safety Issues

- Race Conditions
- **Double-Checked Locking**

Singleton Pattern: The Bad

Global State

Tight Coupling

Testing Challenges

Hidden Dependencies

Inflexible Initialization

Thread Safety Issues

- Race Conditions
- Double-Checked Locking
- **Synchronization Overhead**

Singleton Pattern: The Bad

Global State

Tight Coupling

Testing Challenges

Hidden Dependencies

Inflexible Initialization

Thread Safety Issues

- Race Conditions
- Double-Checked Locking
- Synchronization Overhead
- **Deadlocks**

Singleton Pattern: The Bad

Global State

Tight Coupling

Testing Challenges

Hidden Dependencies

Inflexible Initialization

Thread Safety Issues

- Race Conditions
- Double-Checked Locking
- Synchronization Overhead
- Deadlocks
- **Resource Management**

Singleton Pattern: The Bad

- Global State
- Tight Coupling
- Testing Challenges
- Hidden Dependencies
- Inflexible Initialization
- Non-Thread Safe Init
- Potential for Misuse

Singleton Pattern: The Bad

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- Potential for Misuse

Alternatives/Modifications

- Dependency Injection

Alternatives/Modifications

- Dependency Injection
- **Factory Method Pattern**

Alternatives/Modifications

- Dependency Injection
- Factory Method Pattern
- **Service Locator Pattern**

Alternatives/Modifications

- Dependency Injection
- Factory Method Pattern
- Service Locator Pattern
- **Inversion of Control (IoC) Containers**

Alternatives/Modifications

- Dependency Injection
- Factory Method Pattern
- Service Locator Pattern
- Inversion of Control (IoC) Containers
- **Prototype Pattern**

Alternatives/Modifications

- Dependency Injection
- Factory Method Pattern
- Service Locator Pattern
- Inversion of Control (IoC) Containers
- Prototype Pattern
- **Thread-Safe Singleton Initialization**

Alternatives/Modifications

- Dependency Injection
- Factory Method Pattern
- Service Locator Pattern
- Inversion of Control (IoC) Containers
- Prototype Pattern
- Thread-Safe Singleton Initialization
- **Enum Singleton**

Alternatives/Modifications

- Dependency Injection
- Factory Method Pattern
- Service Locator Pattern
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- Prototype Pattern
- Thread-Safe Singleton Initialization
- Enum Singleton
- **Immutable Objects**

Alternatives/Modifications

- Dependency Injection
- Factory Method Pattern
- Service Locator Pattern
- Inversion of Control (IoC) Containers
- Prototype Pattern
- Thread-Safe Singleton Initialization
- Enum Singleton
- Immutable Objects

Alternatives/Modifications

- Dependency Injection
- Factory Method Pattern
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- Inversion of Control (IoC) Containers
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- Thread-Safe Singleton Initialization
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- Immutable Objects

Observer Pattern

Reevaluating Software Design Patterns

Observer Pattern

Key Components

- Subject

Observer Pattern

Key Components

- Subject
- Observer

Observer Pattern

Key Components

- Subject
- Observer
- Concrete Subject

Observer Pattern

Key Components

- Subject
- Observer
- Concrete Subject
- Concrete Observer

Observer Pattern

Key Components

- Subject
- Observer
- Concrete Subject
- Concrete Observer

Workflow

Observer Pattern

Key Components

- Subject
- Observer
- Concrete Subject
- Concrete Observer

Workflow

- Registration

Observer Pattern

Key Components

- Subject
- Observer
- Concrete Subject
- Concrete Observer

Workflow

- Registration
- Notification

Observer Pattern

Key Components

- Subject
- Observer
- Concrete Subject
- Concrete Observer

Workflow

- Registration
- Notification
- Update

Demo: Observer Pattern

Subject

```
public interface ISubject
{
    void RegisterObserver(IObserver observer);
    void RemoveObserver(IObserver observer);
    void NotifyObservers();
    string Name { get; init; }
}
```

Observer

```
public interface IObserver
{
    void Update(double stockPrice);
    string Name { get; init; }
}
```

Concrete Subject

```
public record StockMarket(string Name) : ISubject
{
  private double _stockPrice;
  private readonly List<IObserver> _observers = [];

  public void SetStockPrice(double price)
  {
    _stockPrice = price;
    NotifyObservers();
  }

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

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

  public void NotifyObservers()
  {
    foreach (var observer in _observers)
    {
      observer.Update(_stockPrice);
    }
  }
}
```

Concrete Subject

```
public record StockMarket(string Name) : ISubject
{
  pri
  pri

  pub
  {
    _
    NotifyObservers();
  }

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

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

  public void NotifyObservers()
  {
    foreach (var observer in _observers)
    {
      observer.Update(_stockPrice);
    }
  }
}
```

```
private double _stockPrice;
private readonly List<IObserver> _observers = [];
```

Concrete Subject

```
public record StockMarket(string Name) : ISubject
{
  pri
  pri

  pub
  {
    _
    NotifyObservers();
  }

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

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

  public void NotifyObservers()
  {
    foreach (var observer in _observers)
    {
      observer.Update(_stockPrice);
    }
  }
}
```

```
private double _stockPrice;
private readonly List<IObserver> _observers = [];
```

Concrete Subject

```
public record StockMarket(string Name) : ISubject
{
    private readonly List<IObserver> _observers = new();

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

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

    public void NotifyObservers(Stock stock)
    {
        foreach (var observer in _observers)
        {
            observer.Update(stock);
        }
    }
}
```

Concrete Subject

```
public record StockMarket(string Name) : ISubject
{
    private readonly List<IObserver> _observers = new();

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

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

    public void NotifyObservers(Stock stock)
    {
        foreach (var observer in _observers)
        {
            observer.Update(stock);
        }
    }
}
```

Concrete Subject

```
public record StockMarket(string Name) : ISubject
{
  priv
  priv

  pub
  {
    _
    No
  }

  pub
  {
    _
  }

  pub
  {
    _
  }

  pub
  {
    foreach (var observer in _observers)
    {
      observer.Update(_stockPrice);
    }
  }
}
```

```
public void NotifyObservers()
{
    foreach (var observer in _observers)
    {
        observer.Update(_stockPrice);
    }
}
```

Concrete Subject

```
public record StockMarket(string Name) : ISubject
{
  priv
  priv

  pub
  {
    _
    No
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  pub
  {
    _
  }

  pub
  {
    _
  }

  pub
  {
    foreach (var observer in _observers)
    {
      observer.Update(_stockPrice);
    }
  }
}
```

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public void NotifyObservers()
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    foreach (var observer in _observers)
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        observer.Update(_stockPrice);
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Concrete Subject

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public record StockMarket(string Name) : ISubject
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  {
    _
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  public void RemoveObserver(IObserver observer)
  {
    _observers.Remove(observer);
  }

  public void NotifyObservers()
  {
    foreach (var observer in _observers)
    {
      observer.Update(_stockPrice);
    }
  }
}
```

```
public void SetStockPrice(double price)
{
    _stockPrice = price;
    NotifyObservers();
}
```

Concrete Subject

```
public record StockMarket(string Name) : ISubject
{
  priv
  priv

  pub
  {
    _
    No
  }

  pub
  {
    _
  }

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

  public void NotifyObservers()
  {
    foreach (var observer in _observers)
    {
      observer.Update(_stockPrice);
    }
  }
}
```

```
public void SetStockPrice(double price)
{
    _stockPrice = price;
    NotifyObservers();
}
```

Concrete Observer

```
public record Investor(string Name) : IObserver
{
  public void Update(double stockPrice)
    => Console.WriteLine($"Stock price for {Name} is {stockPrice}");
}
```

Implementation

```
// Create a stock market
StockMarket stockMarket = new("Omni Consumer Products");

// Create investors
Investor investor1 = new("John");
Investor investor2 = new("Alice");

// Register investors with the stock market
stockMarket.RegisterObserver(investor1);
stockMarket.RegisterObserver(investor2);

// Simulate stock price changes
stockMarket.SetStockPrice(100.00);
stockMarket.SetStockPrice(115.50);

// Investor Alice loses interest and unsubscribes
stockMarket.RemoveObserver(investor2);

// More stock price changes
stockMarket.SetStockPrice(98.75);
```

Observer Pattern: The Good

Loose Coupling

Observer Pattern: The Good

Loose Coupling

Scalability

Observer Pattern: The Good

Loose Coupling

Scalability

Flexibility and Extensibility

Observer Pattern: The Good

- Loose Coupling
- Scalability
- Flexibility and Extensibility
- Reusability

Observer Pattern: The Good

- Loose Coupling
- Scalability
- Flexibility and Extensibility
- Reusability
- Maintainability

Observer Pattern: The Good

- Loose Coupling
- Scalability
- Flexibility and Extensibility
- Reusability
- Maintainability
- Dynamic Relationships

Observer Pattern: The Good

- Loose Coupling
- Scalability
- Flexibility and Extensibility
- Reusability
- Maintainability
- Dynamic Relationships

Demo: Observer Pattern Problems

Unintended Cascading Updates

```
public record Investor(string Name) : IObserver
{
  public void Update(double stockPrice)
  {
    Console.WriteLine($"Stock price for {Name} is {stockPrice}");

    if (stockPrice > 110.00)
    {
      Console.WriteLine($"Investor {Name} decides to sell stocks.");
    }
  }
}
```

Observer Pattern: The Bad

Performance

Observer Pattern: The Bad

Performance

Memory Leaks

Observer Pattern: The Bad

- Performance
- Memory Leaks
- **Ordering Dependencies**

Observer Pattern: The Bad

- Performance
- Memory Leaks
- Ordering Dependencies
- Unintended Cascading Updates

Observer Pattern: The Bad

- Performance
- Memory Leaks
- Ordering Dependencies
- Unintended Cascading Updates
- Security Concerns

Observer Pattern: The Bad

- Performance
- Memory Leaks
- Ordering Dependencies
- Unintended Cascading Updates
- Security Concerns
- Tight Coupling

Observer Pattern: The Bad

- Performance
- Memory Leaks
- Ordering Dependencies
- Unintended Cascading Updates
- Security Concerns
- Tight Coupling
- Debugging Difficulty

Observer Pattern: The Bad

- Performance
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Alternatives/Modifications

- Event Aggregator Pattern

Alternatives/Modifications

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- **Reactive Extensions (Rx)**

Alternatives/Modifications

- Event Aggregator Pattern
- Reactive Extensions (Rx)
- **Mediator Pattern**

Alternatives/Modifications

- Event Aggregator Pattern
- Reactive Extensions (Rx)
- Mediator Pattern
- **Callback/Delegate Approach**

Alternatives/Modifications

- Event Aggregator Pattern
- Reactive Extensions (Rx)
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- **Message Queue Pattern**

Alternatives/Modifications

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- Reactive Extensions (Rx)
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- Callback/Delegate Approach
- Message Queue Pattern
- **State Pattern**

Alternatives/Modifications

- Event Aggregator Pattern
- Reactive Extensions (Rx)
- Mediator Pattern
- Callback/Delegate Approach
- Message Queue Pattern
- State Pattern
- **Command Pattern**

Alternatives/Modifications

- **Event Aggregator Pattern**
- Reactive Extensions (Rx)
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- Callback/Delegate Approach
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- State Pattern
- Command Pattern

Alternatives/Modifications

- Event Aggregator Pattern
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Factory Pattern

Reevaluating Software Design Patterns

Key Components and Concepts

Factory Pattern

Factory Interface/ Abstract Class

Key Components and Concepts

Factory Pattern

Factory Interface/ Abstract Class

Concrete Factories

Key Components and Concepts

Factory Pattern

Factory Interface/ Abstract Class

Concrete Factories

Product Interface/ Abstract Class

Key Components and Concepts

Factory Pattern

Factory Interface/ Abstract Class

Concrete Factories

Product Interface/ Abstract Class

Concrete Products

Key Components and Concepts

Factory Pattern

Factory Interface/ Abstract Class

Concrete Factories

Client

Product Interface/ Abstract Class

Concrete Products

Key Components and Concepts

Factory Pattern

Factory Interface/ Abstract Class

Concrete Factories

Client

Product Interface/ Abstract Class

Concrete Products

Demo: Factory Pattern

Product

```
public interface IProduct
{
  void Display();
}

public class ConcreteProductA : IProduct
{
  public void Display() => Console.WriteLine("Concrete Product A");
}

public class ConcreteProductB : IProduct
{
  public void Display() => Console.WriteLine("Concrete Product B");
}
```

Product

```
public interface IProduct
{
  void Display();
}
```

```
public class ConcreteProductA : IProduct
{
  public void Display() => Console.WriteLine("Concrete Product A");
}

public class ConcreteProductB : IProduct
{
  public void Display() => Console.WriteLine("Concrete Product B");
}
```

Product

```
public interface IProduct
{
  void Display();
}
```

```
public class ConcreteProductA : IProduct
{
  public void Display() => Console.WriteLine("Concrete Product A");
}

public class ConcreteProductB : IProduct
{
  public void Display() => Console.WriteLine("Concrete Product B");
}
```

Factory

```
public interface IFactory
{
   IProduct CreateProduct();
}

public class ConcreteFactory : IFactory
{
   public IProduct CreateProduct()
   {
      return new ConcreteProductA();
   }
}
```

Client

```
IFactory factoryA = new ConcreteFactoryA();

IProduct productA = factoryA.CreateProduct();
productA.Display();

IProduct productB = factoryA.CreateProduct();
productB.Display();
```

Factory Pattern: The Good

Abstraction and Encapsulation

Factory Pattern: The Good

Abstraction and Encapsulation

Flexibility and Extensibility

Factory Pattern: The Good

- Abstraction and Encapsulation
- Flexibility and Extensibility
- Centralized Control

Factory Pattern: The Good

- Abstraction and Encapsulation
- Flexibility and Extensibility
- Centralized Control
- Code Maintenance

Factory Pattern: The Good

- Abstraction and Encapsulation
- Flexibility and Extensibility
- Centralized Control
- Code Maintenance

- Code Readability

Factory Pattern: The Good

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Overhead

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Excessive Abstraction

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Alternatives to the Factory Pattern

- Direct Instantiation

Alternatives to the Factory Pattern

- Direct Instantiation
- **Builder Pattern**

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- Direct Instantiation
- Builder Pattern
- **Abstract Factory Pattern**

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- Direct Instantiation
- Builder Pattern
- Abstract Factory Pattern
- **Static Factory Method**

Alternatives to the Factory Pattern

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- Static Factory Method
- **Service Locator Pattern**

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Importance of Context

Reevaluating Software Design Patterns

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Problem Suitability

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Project Requirements

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- Problem Suitability
- Project Requirements
- Team Expertise

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- Problem Suitability
- Project Requirements
- Team Expertise
- Technology Stack

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- Problem Suitability
- Project Requirements
- Team Expertise
- Technology Stack
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Thank You

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