SOFTWARE ENGINEERING
(Week-13)

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AGENDA OF WEEK # 13

Architecture Metrics (Cont..)

Software Design Quality

- SOLID Principles

ARCHITECTURAL DESIGN METRICS (cont…)

SIZE METRICS

1. No of Components (NC)

- No of components (NC) metric is used to count the number of components in a system. The NC metric indicates the system size that is used in estimating the complexity of the system.

$$NC(SyS) = \sum_{C \in SyS}^{n} 1$$

SIZE METRICS

2. No of Operations(NO)

- NO is a count of all the operations of a component to indicate the complexity of a component.

$$NO(C) = \sum_{O \in C}^{n} 1$$

- To calculate the overall NO of all components in a system.

$$NO(SyS) = \sum_{O \in SyS}^{n} 1$$

COUPLING METRICS

1. Direct Coupling

- The direct coupling can be defined as the direct interactions between consumers and providers. Direct coupling can be calculated by counting all the direct consumer calls for a specific provider (component) as shown below.

$$DC\ (p) = C\ (p)$$

2. Indirect Coupling (IC)

- The indirect coupling was calculated by counting the direct consumers calls for specific providers and then assume consumers as providers and calculate their coupling.

$$IC(p) = DC\ (p) + \sum_{c(p) \epsilon P} \mathrm{IC(c(p))}$$

COUPLING METRICS

3. Total Coupling

- The total coupling can be calculated by the addition of direct and indirect coupling, as shown in the equation below.

$$TCoup = DC(p) + IC(p)$$

4. Coupling Factor (CoupF)

- The quantitative result of total coupling could not be interpreted directly, because this number may give a good indication if the system is big or worse if it is small. This means that the size of the system is needed to understand the value of this metric. If we suppose f = NC (SyS) + NO (SyS) then:

$$CopF(SyS) = \frac{TCoup(SyS)}{f2 - f}$$

COHESION METRICS

1. Cohesion Metric

This metric was used to measure the degree of cohesion for specific component(C). Cohesion is a relationship between the operations of a component.

CM (C) = counts all the consumers that consume the functionalities

The consumer here refers to the operations of a service. The remaining operations are the value of this metric.

COHESION METRICS

2. Cohesion Factor

- Just like the coupling factor, the result given by the cohesion metric could not be interpreted directly, rather it depends on the system size. If the system is big, the result of this metric may provide a good indication, else the indication would be bad. Let f = NC(SyS) + NO(SyS) and i = NC(c) + NO(c) then

$$CohF(C) = \frac{CM(C) * (i^2 - i)}{f2 - f}$$

$$CohF(SyS) = \sum_{C \in SyS} \frac{CM(C) * (i^2 - i)}{f2 - f}$$

COMPLEXITY METRICS

1. Total Complexity Metric for a Component

- This metric calculates the complexity of component(c) from coupling and cohesion metrics.

$$TCM(C) = \frac{TCoup(C) + NC(C) + NO(C)}{CM(C)}$$

2. Complexity Factor (ComF)

- This metric calculates the complexity factor by using coupling and cohesion factors.

$$ComF(C) = \frac{CopF(C)}{CohF(C)}$$

COMPLEXITY METRICS

3. Total Complexity Metric for a System

- This metric calculates the complexity of the entire system by using the previous two metrics.

$$TCM(SyS) = \sum_{C \epsilon SyS} TCM(C) * ComF(C)$$

REUSABILITY METRICS

1. Reusability Metric

- Reusability can be calculated in terms of coupling, by counting the entire direct and indirect consumer calls for a specific provider.

$$Res = TCoup = DC(p) + IC(p)$$

2. Reusability Factor:

- The reusability factor can be calculated by comparing reusability values (in terms of coupling) with the system size by measuring the cohesion of operations.

$$ResF = \frac{CM(SyS)}{TCoup(SyS)}$$

MAINTAINABILITY METRICS

In the literature, the most common characteristics related to maintainability are coupling, cohesion and complexity.

Cohesion

[Cohesion] positively impacts (+) → [maintainability]

Coupling

[Coupling] negatively impacts (-) → [maintainability]

No of complex component (NCC)

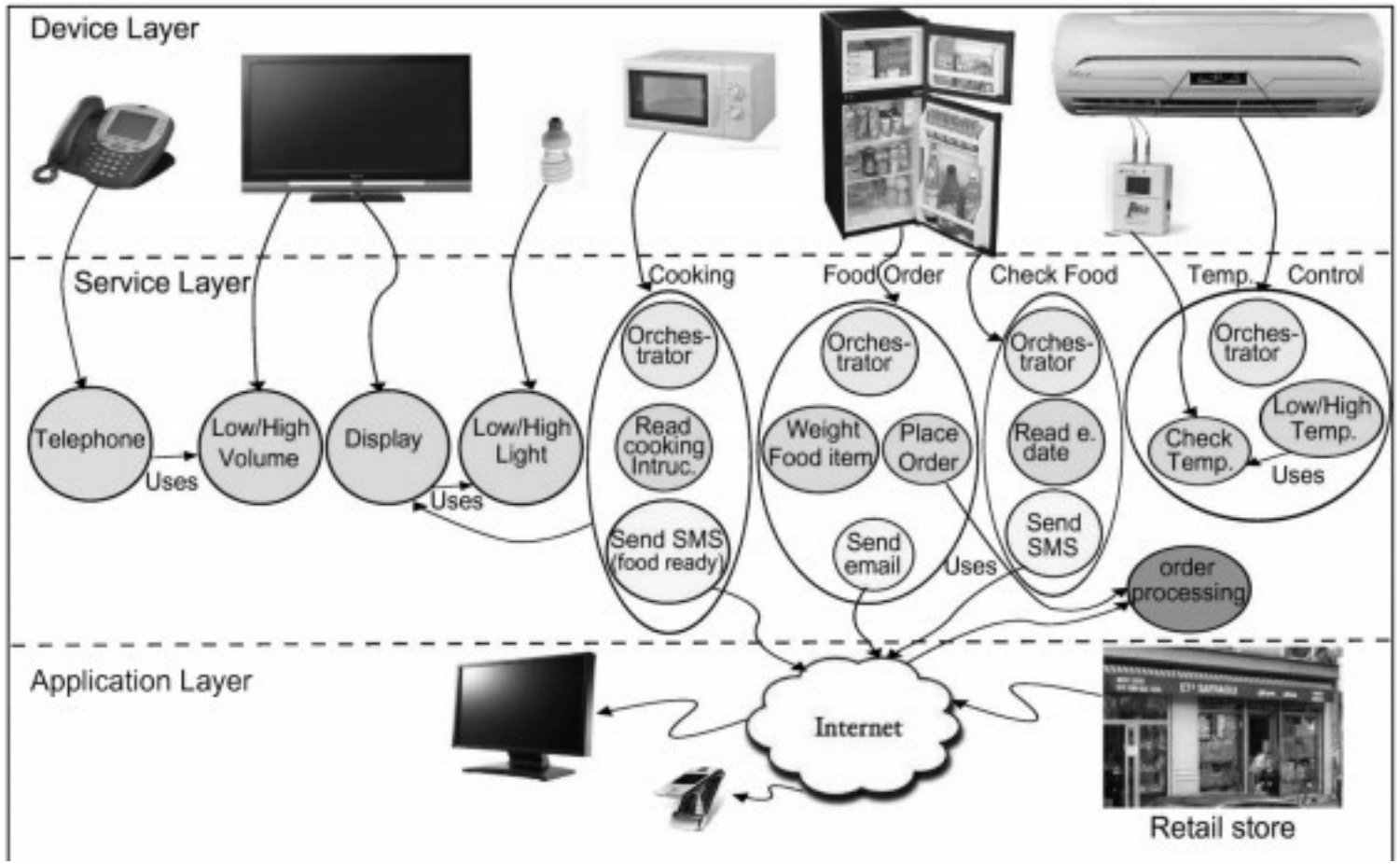
[NCC] negatively impacts (-) → [maintainability]

Complexity

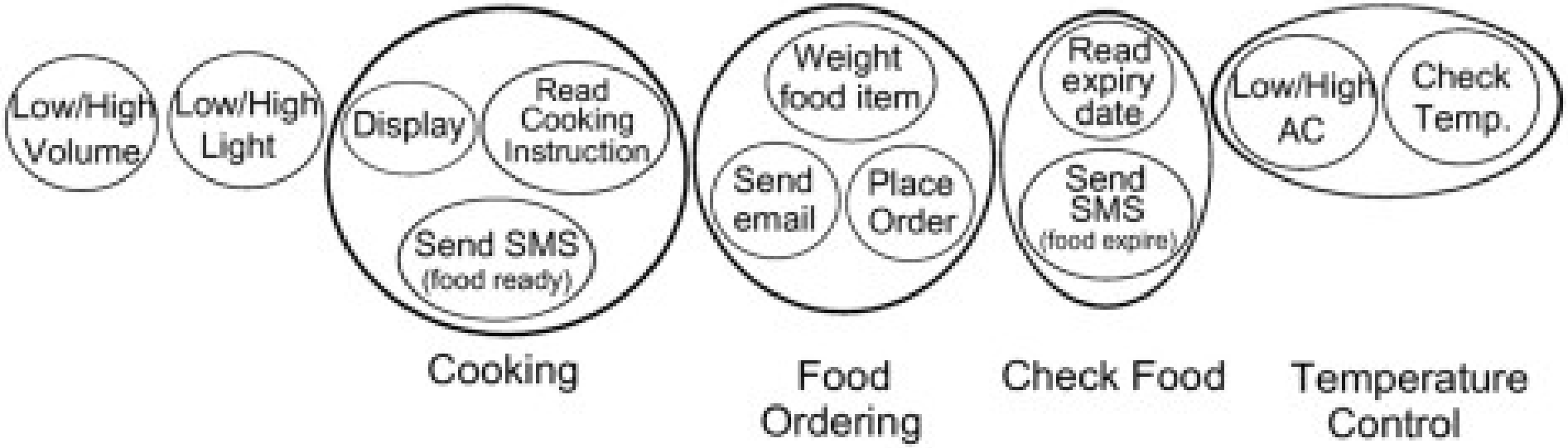
[Complexity] negatively impacts (-) → [maintainability]

SMART HOME CASE STUDY

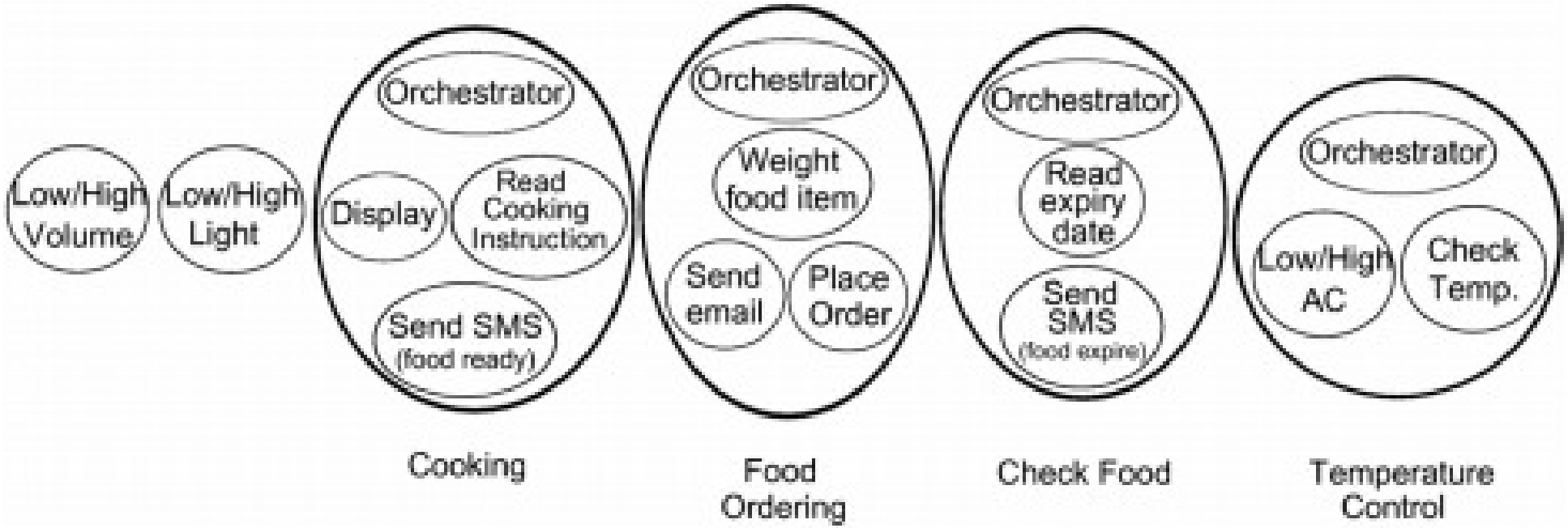
SOA OF SMART HOME



SIMPLE VS COMPOSITE SERVICES



INTRODUCE CONTROL SERVICE



SOFTWARE DESIGN QUALITY

SOLID Principle

1. Single Responsibility Principle
2. Open Close Principle
3. Liskov Substitution Principle
4. Interface Segregation Principle
5. Dependency Inversion Principle

SINGLE RESPONSIBILITY PRINCIPLE

SINGLE RESPONSIBILITY PRINCIPLE

Single responsibility means that your class (any entity for that matter, including a method in a class, or a function in structured programming) should only do one thing.

A class should have only one reason to change.

Related to Coupling & Cohesion.

SINGLE RESPONSIBILITY PRINCIPLE

What a class does?

The more a class does, the more likely it will change.

The more a class changes, the more likely we will introduced bugs.

One of the simples principle but one of the most difficult to get right.

SRP EXAMPLE

```
Class Post{
void CreatePost (Database db, string postMessage) {
try{
      db.Add(postMessage);
      }
catch (Exception ex)
      {
      db.LogError("An error occurred:", ex.ToString());
      File.WriteAllText("\LocalErrors.txt", ex.ToString());
      }
   }
}
```

SOLUTION

```
Class Post{
Private ErrorLogger errorlLogger = new ErrorLogger();
void CreatePost (Database db, string postMessage) {
try{
        db.Add(postMessage);
        }
catch (Exception ex)
        {
        errorLogger.log(ex.ToString());
        }
   }
}
```

```
Class ErrorLogger {
        void log(string error)
        {
        db.LogError("An error occurred:", error);
        File.WriteAllText("\LocalErrors.txt", error);
          }
}
```

OPEN CLOSE DESIGN PRINCIPLE

OPEN CLOSE DESIGN PRINCIPLE

"Software entities like classes, modules and functions should be open for extension but closed for modifications"

Bertrand Meyer

OPEN CLOSE DESIGN PRINCIPLE

The ***Open Close Principle*** states that the design and writing of the code should be done in a way that new functionality should be added with minimum changes in the existing code.

The design should be done in a way to allow the adding of new functionality as new classes, keeping as much as possible existing code unchanged.

OPEN CLOSE DESIGN PRINCIPLE

Open-closed principle have two primary attributes:

I. They are “Open For Extension”

This means that the behavior of the module can be extended. That we can make the module behave in new and different ways as the requirements of the application change, or to meet the needs of new applications.

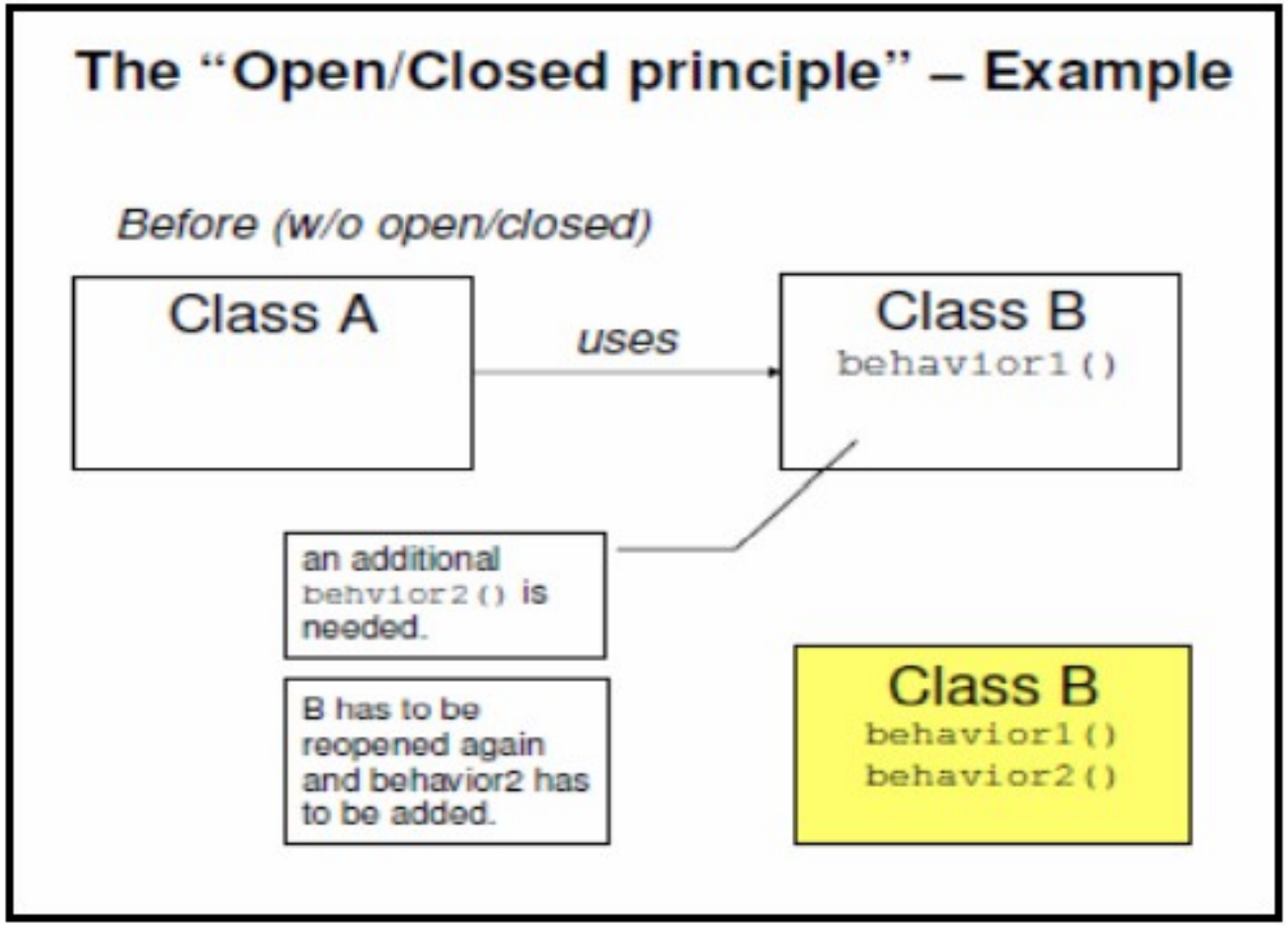
II. They are “Closed for Modification”

No one is allowed to make changes in source code.

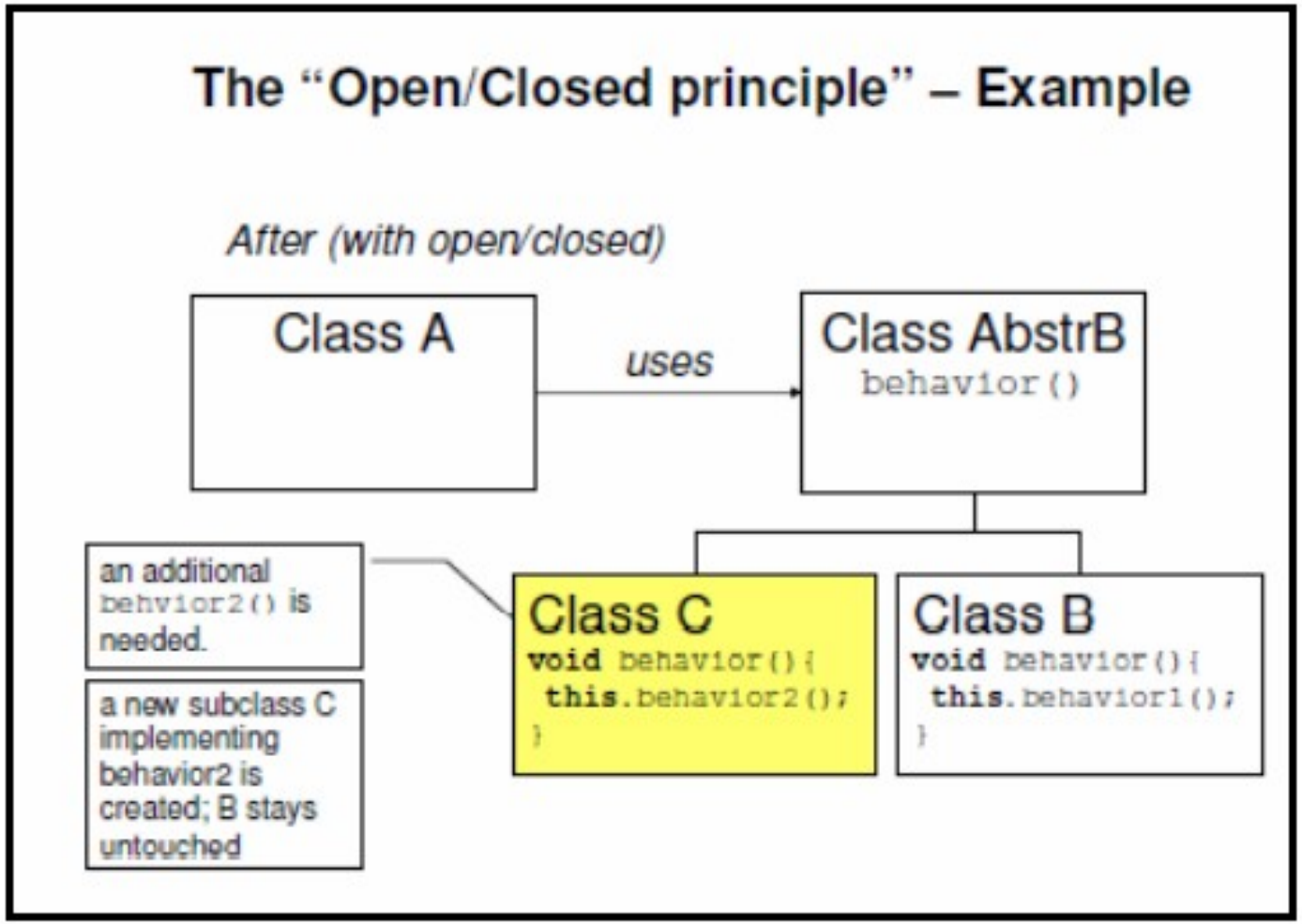
OPEN CLOSE DESIGN PRINCIPLE

The Open/Closed principle can be applied in be applied in object oriented paradigms with the help of inheritance and polymorphism:

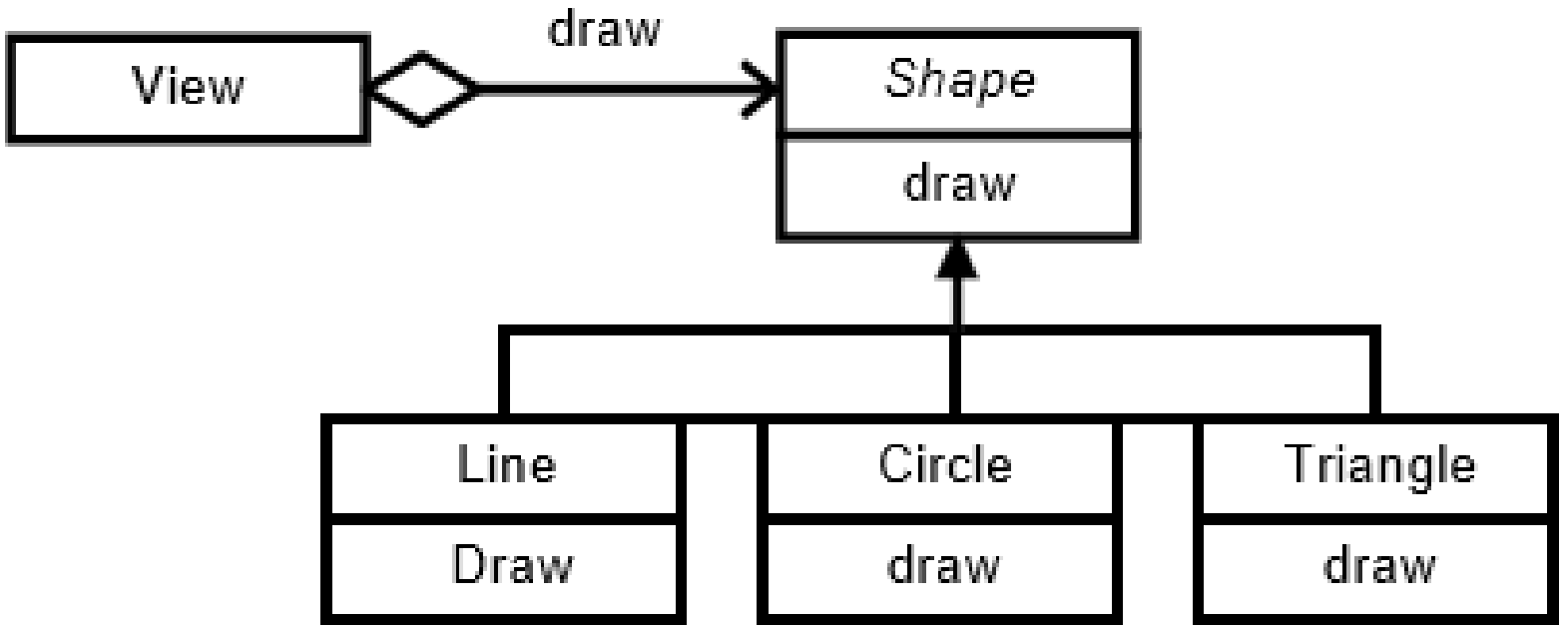
OPEN CLOSE DESIGN PRINCIPLE



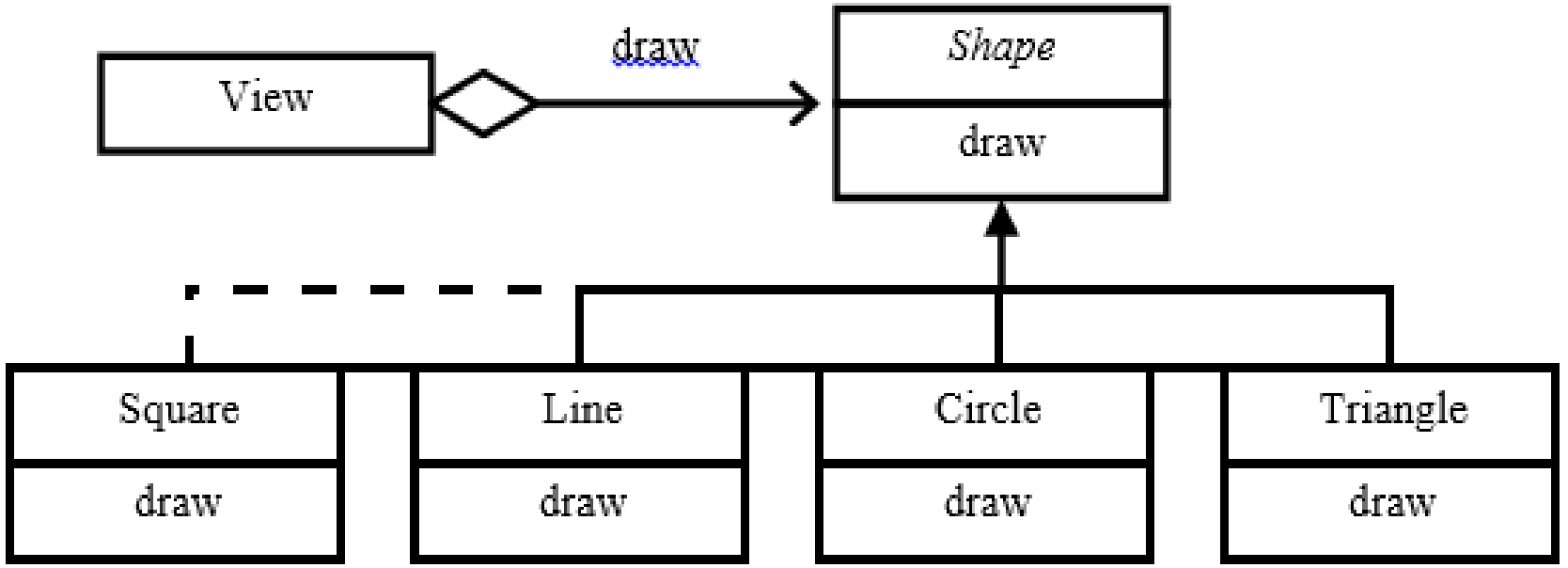
OPEN CLOSE DESIGN PRINCIPLE



EXAMPLE



EXAMPLE



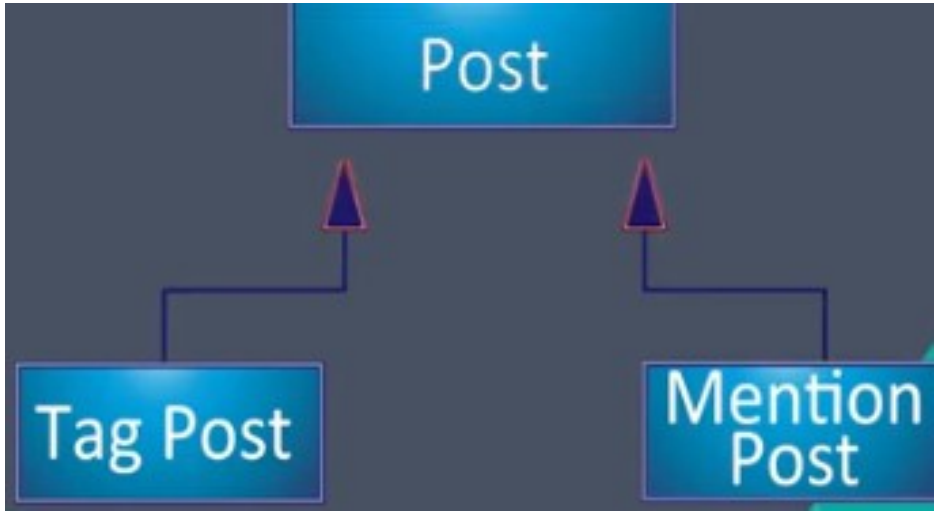
In general, polymorphism is a powerful tool to develop flexible and reusable systems

OCP EXAMPLE

```
Class Post{
void CreatePost (Database db, string postMessage) {
        If (postMessage.StartsWith("#"))
            {
            db.AddAsTag(postMessage);
            }
        else
            {
            db.Add(postMessage);
            }
   }
}
```

SOLUTION

```
class Post
{
    void CreatePost(Database db,
                    string postMessage)
    {
        db.Add(postMessage);
    }
}
```



LISKOV SUBSTITUTION PRINCIPLE

LISKOV SUBSTITUTION PRINCIPLE

The principle defines that objects of a superclass shall be replaceable with objects of its subclasses without breaking the application. That requires the objects of your subclasses to behave in the same way as the objects of your superclass.

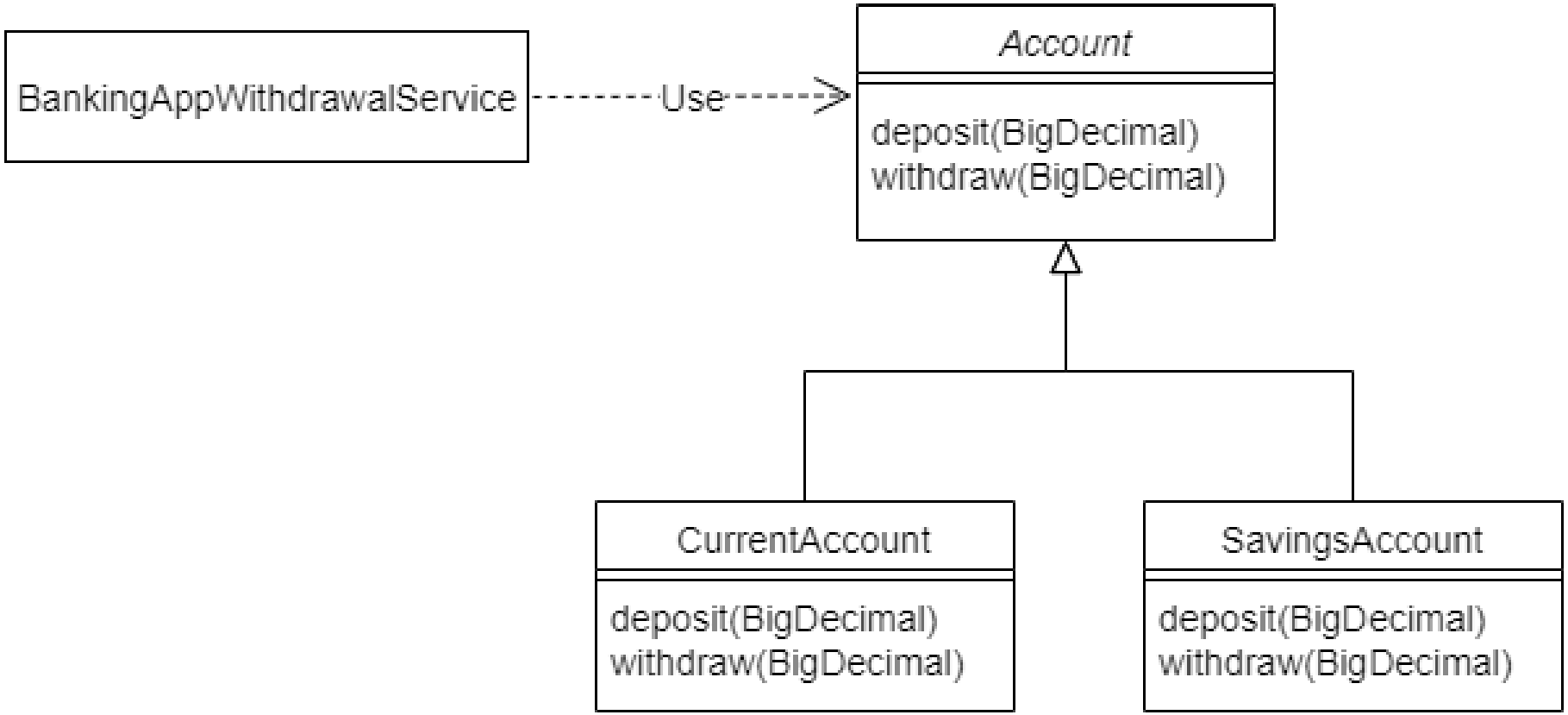
If substituting a superclass object with a subclass object changes the program behavior in unexpected ways, the LSP is violated.

The LSP is applicable when there's a super-type sub-type inheritance relationship by either extending a class or implementing an interface.

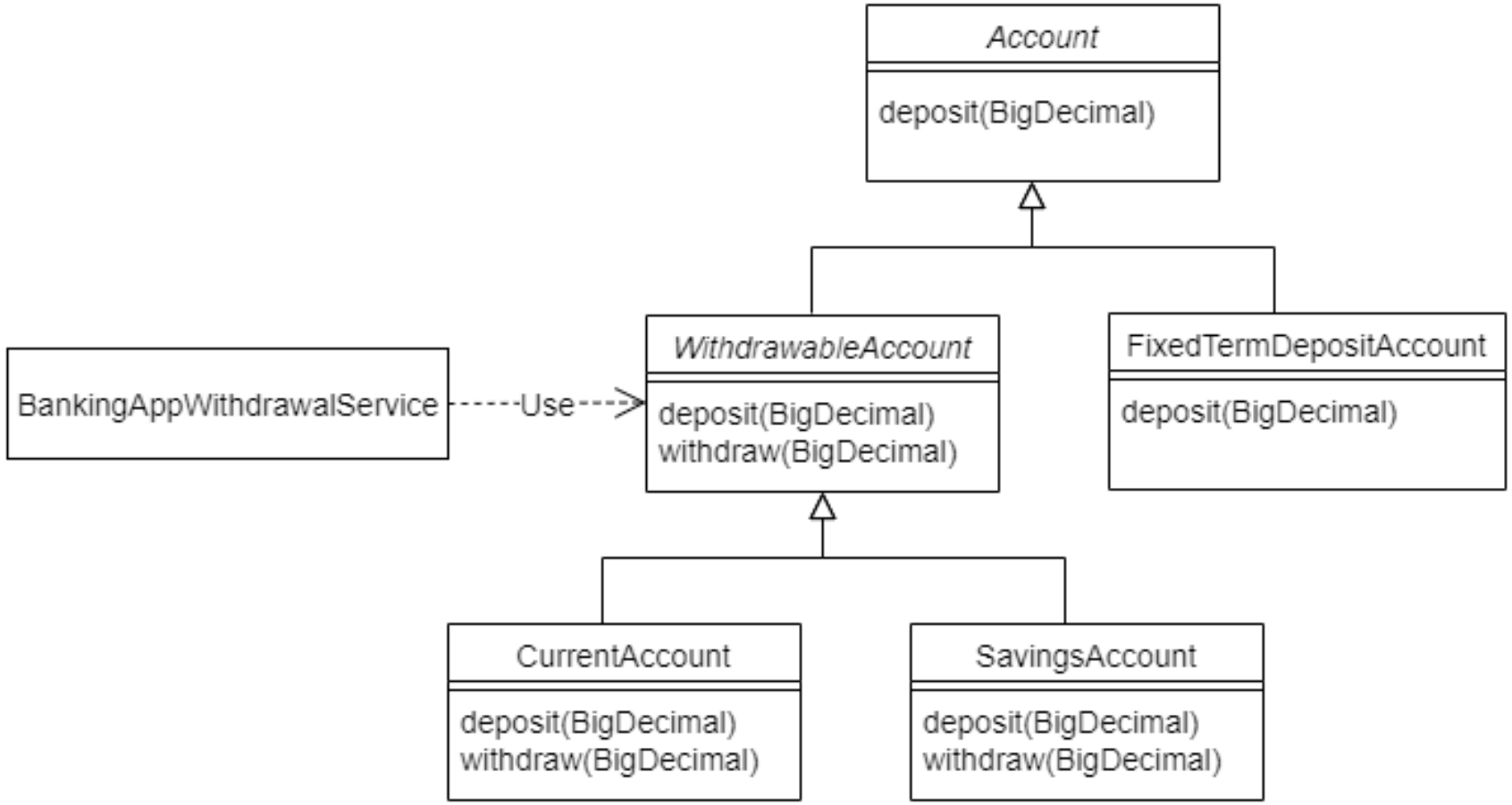
LSP IMPORTANCE

Liskov Substitution Principle actually teaches the exact meaning of inheritance.

EXAMPLE


BankingAppWithdrawalService
Use
Account
deposit(BigDecimal)
withdraw(BigDecimal)
CurrentAccount
deposit(BigDecimal)
withdraw(BigDecimal)
SavingsAccount
deposit(BigDecimal)
withdraw(BigDecimal)

EXAMPLE


Account
deposit(BigDecimal)
WithdrawableAccount
deposit(BigDecimal)
withdraw(BigDecimal)
FixedTermDepositAccount
deposit(BigDecimal)
BankingAppWithdrawalService
Use
CurrentAccount
deposit(BigDecimal)
withdraw(BigDecimal)
SavingsAccount
deposit(BigDecimal)
withdraw(BigDecimal)

INTERFACE SEGREGATION PRINCIPLE

INTERFACE SEGREGATION PRINCIPLE

“Clients should not be forced to depend upon interfaces that they do not use.”

INTERFACE SEGREGATION PRINCIPLE

If you have an abstract class or an interface, then the implementers should not be forced to implement parts that they don’t care about.

In programming, the ISP states that no client should be forced to depend on methods it does not use.

INTERFACE SEGREGATION PRINCIPLE

Don’t add additional functionality to an existing interface by adding new methods.

Instead create a new interface and let your class implement multiple interfaces if needed.

INTERFACE SEGREGATION PRINCIPLE

ISP deals with non cohesive interfaces and it reduces coupling in a system.

ISP (EXAMPLE)

Violation of ISP

```
Interface iPost {
Void CreatPost();
Void ReadPost();
}
```

```
Interface iPostCreate {
Void CreatPost();
}
Interface iPostRead {
Void ReadPost();
}
```

ISP (EXAMPLE)

Violation of ISP

```
Interface ISmartDevice{
void Print();
void Fax();
void Scan();
}
```

```
class AllinOnePrinter implements ISmartDevice{
public void Print() {
    }
public void Fax() {
    }
public void Scan() {
    }
}
```

ISP EXAMPLE

Now suppose we need to handle a new device (EconomicPrinter class) that can only print. We're forced to implement the Whole interface.

```
class EconomicPrinter implements Iprinter{
    public void Print()   {
        }
    public void Fax()   {
    throw new NotSupportedException();
        }
    public void Scan() {
    throw new NotSupportedException();
        }
}
```

SOLUTION

```
interface Iprinter {
void Print();
}
interface Ifax {
void Fax();
}
interface Iscanner{
void Scan();
}
```

```
class EconomicPrinter implements ISmartDevice{
   public void Print()   {
      }
}
```

SOLUTION

```
class EconomicPrinter implements
Iprinter, Ifax, Iscanner{
    public void Print()   {
        }
    public void Fax()   {
        }
    public void Scan() {
        }
}
```

ISP

The ISP guides us to create many small interfaces with coherent functionalities instead of a few big interfaces with lots of different methods.

When we apply the ISP, class and their dependencies communicate using focused interfaces, minimizing dependencies.

Smaller interfaces are easier to implement, improving flexibility and the possibility of reuse.

DEPENDENCY INVERSION PRINCIPLE

DEPENDENCY INVERSION PRINCIPLE

1. High Level Modules should not depend on low level modules. Both should depend on abstractions.

2. Abstractions should not depend upon details. Details should depend upon abstractions.

DEPENDENCY INVERSION PRINCIPLE

In programming., the dependency inversion principle is a way to decouple software modules.

OCP, LSP, and even SRP lead to the dependency inversion principle.

DEPENDENCY INJECTION

Dependency Injection

Injecting any dependencies of a class through a class constructor as an input parameter.

Injection basically converts composition to association.

Strong coupling to weak coupling.

DIP (EXAMPLE)

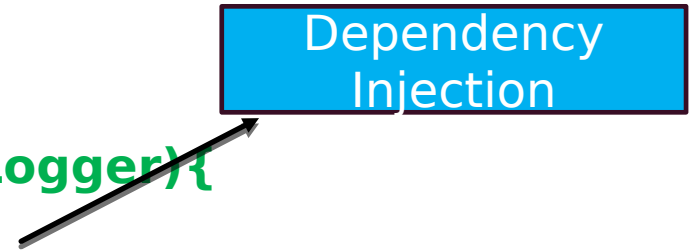
```
Class Post{
Private ErrorLogger errorlLogger = new ErrorLogger();
void CreatePost (Database db, string postMessage) {
try{
        db.Add(postMessage);
        }
catch (Exception ex)
        {
        errorLogger.log(ex.ToString());
        }
   }
}
```

Dependency

```
Class ErrorLogger {
        void log(string error)
        {
        db.LogError("An error occurred:", error);
        File.WriteAllText("\LocalErrors.txt", error);
          }
}
```

SOLUTION

```
Class Post{
Private Logger _logger;
Public Post (Logger injectedLogger){
    logger = injectedLogger;
    }
void CreatePost (Database db, string postMessage) {
        {
        .....
        .....
        }
}
```



HAVE A GOOD DAY!