SOLID

Principles for Maintainability of Code

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Quality Factors

- ISO/IEC 25010
  - Functional Suitability
  - Performance efficiency
  - Compatibility
  - Usability
  - Reliability
  - Security
  - Maintainability
  - Portability

Quality Factors - Maintainability

- Modularity
- Reusability
- Analysability
- Modifiability
- Testability

S O L I D

- **S** Single Responsibility
- **O** Open / Closed
- **L** Liskov Substitution
- **I** Interface Segregation
- **D** Dependency Injection/Inversion

The Single Responsibility Principle

- Heard of High Cohesion ?
  one of the GRASP (General Responsibility Assignment Software Patterns) patterns

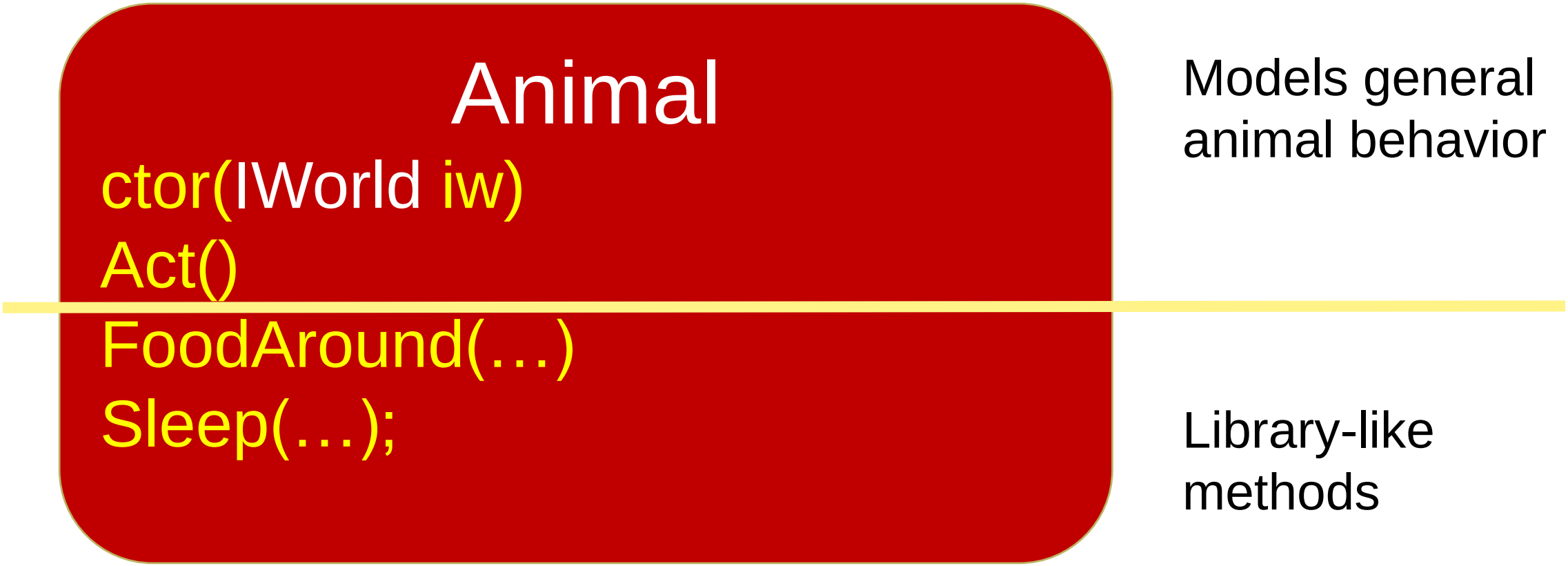
- Code that changes for the same reasons should be **grouped together**
- Code that changes for different reasons should be **separated**

- Classes should only have **one** main responsibility
- => classes should only have **one** reason to change
- Keep classes small, focused and abstract

The Single Responsibility Principle

Tanks to Per Laursen

The Single Responsibility Principle



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The Single Responsibility Principle

AnimalBehavior

ctor(IAnimalLibrary
ial)
Act()

AnimalLibrary

ctor(IWorld iw)
FoodAround(…)
Sleep(…);

Tanks to Per Laursen

The Open/Closed Principle

- Software entities should be **open** for extension, but **closed** for modification.
- **Open for extension**: behaviour can be extended with new behaviours
- **Closed for modification**: Extension does not require change in the source code for the entity
- “closed for modification that requires clients of the code to change”

The Open/Closed Principle

```
public class Client
{
    public CalculatorV10 _calculator;                    // ← quite close for modifications
    public Client()
    {
        _calculator = new CalculatorV10();
    }
    public void ProcessData(Data d)
    {
        int result = _calculator.Calculate(d);
        //...
    }
}
```

The Open/Closed Principle

```
public class Client
{
    public ICalculator _calculator;
    public Client(ICalculator calculator)  // ← Now open for modification
    {
        _calculator = calculator;
    }
    public void ProcessData(Data d)
    {
        int result = _calculator.Calculate(d);
    }
}
```

The Interface Segregation principle

- Like Single Responsibility for classes
  - Interfaces must be small and focused

- An example for CRUD

```
public interface ICreateReadUpdateDelete<T>
{
    void Create(int key, T obj);
    T Read(int key);
    void Update(int key, T obj);
    void Delete(int key);
}
```

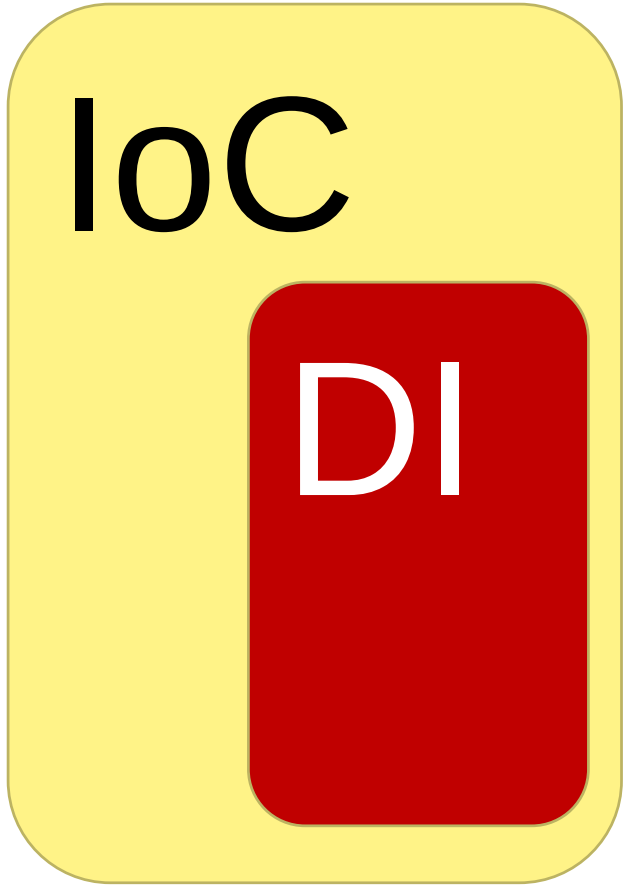
The Interface Segregation principle

- All implementation gets full access to all functionality ! – what if only need get?
- Solution split interface into smaller more focused interfaces e.g.

```
public interface ICreate<T>
{
  void Create(int key, T obj);
}
public interface IRead<T>
{
  T Read(int key);
}
public interface IUpdate<in T>
{
   void Update(int key, T obj);
}
public interface IDelete<T>
{
  void Delete(int key);
}
```

The Dependency Injection/Inversion Principle

- In some SOLID presentations: **Dependency Injection (DI)**
- In other SOLID presentations: **Dependency Inversion**
- **Dependency Inversion**
  aka **Inversion of Control (IoC)**



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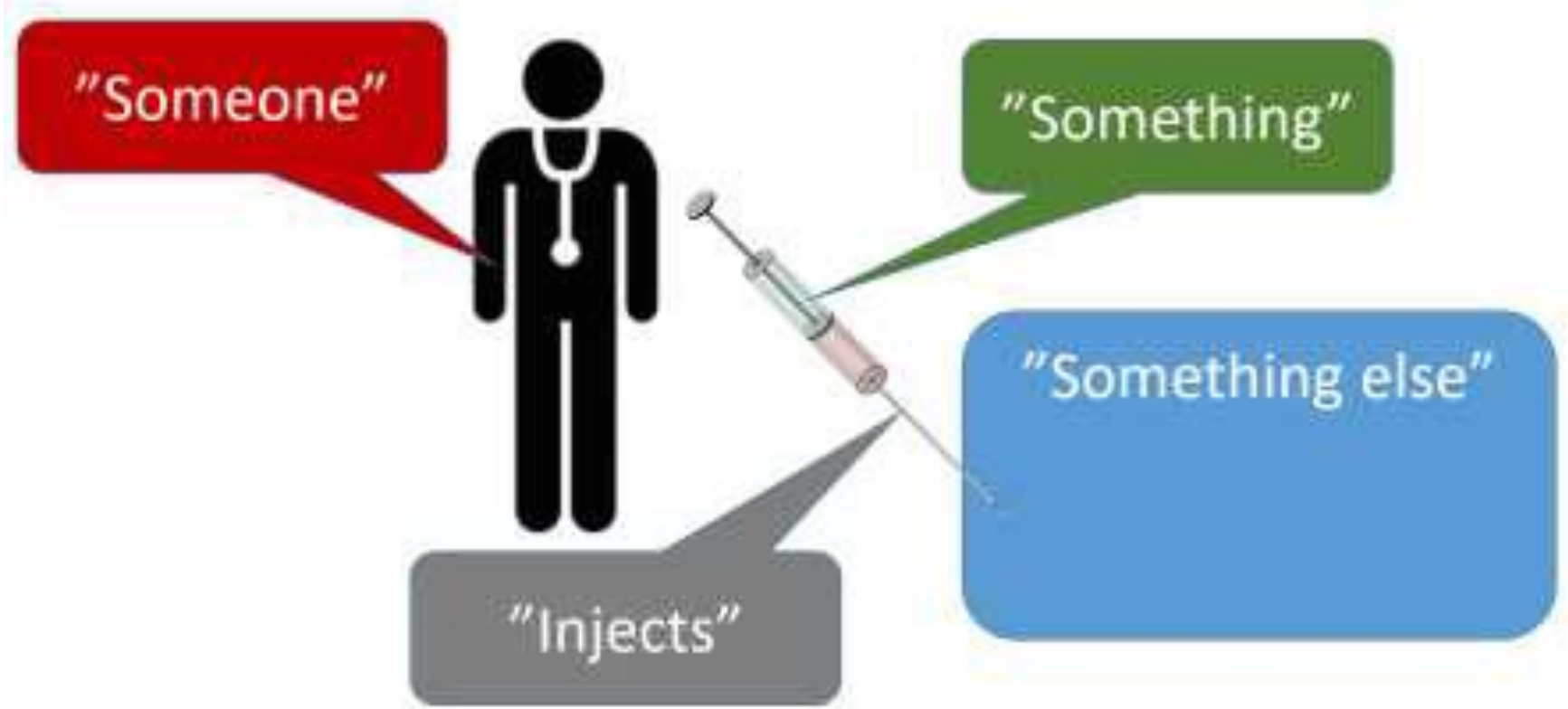
Inversion of Control (IoC)

- **Method Level**
- **Object Level**



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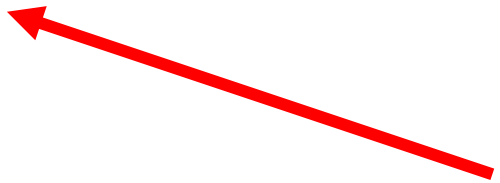
Method-level IoC

```
public class Cat : Animal
{
   public override void Act()
   {
      if (FoodAround("Mouse"))
      {
          HuntMice();
      }
     else
    {
        Sleep();
    }
}
private void HuntMice() { }
private void Sleep() { }
}
```



Hard coded

Method-level IoC – cont.

- Template approach

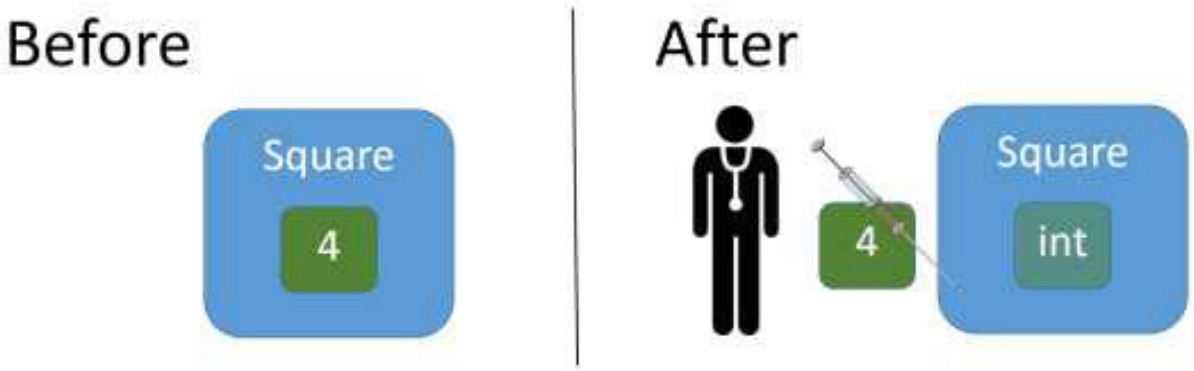
```
public abstract class Animal : IAnimal
{
   public void Act()
   {
      If (FoodAround(PreferredFood()))
      {
          GetFood();
      }
      else
      {
        Idle();
       }
    }
    private bool FoodAround(string food) { return …; }
    protected abstract string PreferredFood();
    protected abstract void GetFood();
    protected abstract void Idle();
}
```

Method-level IoC – cont.

- ***Dependency Injection – parameter level***

```
public int SquareOf4()
{
   return 4 * 4;
}

public int SquareOf6()
{
   return 6 * 6;
}
```

```
public int Square(int n)
{
   return n * n;
}
```



Method-level IoC – cont.

```
public class Die
{
   private int _faceValue;
   private static Random _random = new Random();
   public Die()
   {
      Roll();
   }
   public int FaceValue
   {
       get { return _faceValue; }
    }
    public void Roll()
   {
      _faceValue = _random.Next(0,6) + 1;
   }
}
```



```
public class Die
{
   private int _faceValue;
   private int _noOfSides;
   private static Random _random = new Random();
   public Die(int noOfSides)
   {
      _noOfSides = noOfSides;
      Roll();
    }
    public int FaceValue
    {
       get { return _faceValue; }
     }
    public void Roll()
   {
      _faceValue = _random.Next(0, _noOfSides) + 1;
    }
}
```

Method-level IoC – cont.

- ***Dependency Injection – method level***

```
public List<int> FilterValues(List<int> values)
{
   List<int> filteredValues = new List<int>();
   foreach (var value in values)
   {
      if (value > 10)
     {
         filteredValues.Add(value);
      }
   }
   return filteredValues;
}
```



```
public List<int> FilterValues(List<int> values, Func<int,bool> condition)
{
   List<int> filteredValues = new List<int>();
   foreach (var value in values)
   {
      if (condition(value))
     {
         filteredValues.Add(value);
      }
   }
   return filteredValues;
}
```

Object-level IoC

- ***Dependency Injection – object level***

```
public abstract class Animal : IAnimal
{
  private IWorld TheWorld { get; }
  protected Animal(bool manyOrFew)
  {
    if (manyOrFew)
    {
      TheWorld = new WorldManyAnimals();
    }
    else
   {
      TheWorld = new WorldFewAnimals();
   }
  }
}
```



```
public abstract class Animal : IAnimal
{
   private IWorld TheWorld { get; }

   protected Animal(IWorld theWorld)
   {
      TheWorld = theWorld;
    }
}
```

Exercises

- **SOLID 1**
- **SOLID 2**

The Liskov Substitution Principle

- Definition

If the class S is a subtype of the class T,
then objects of type T may be replaced with objects of type S,
without breaking the program

The Liskov Substitution Principle

- Principle relating to how to create inheritance hierarchies
- Ensures that a client can use subclasses of provided classes **without** changing the expected behaviour

The Liskov Substitution Principle

```
public class S : T
{
    public override void SayHello(string name)
    {
        Console.WriteLine($"Hola {name}");
    }
}
```

The Liskov Substitution Principle

```
public class Client
{
   public void DoSomething(T obj)
   {
      obj.SayHello("Alex");
      obj.SayHello("Betty");
   }
}

Client aClient = new Client();
aClient.DoSomething(new T());
aClient.DoSomething(new S()); // Have I broken something…?
```

The Liskov Substitution Principle

```
// What does this interface do…?
public interface IT
{
   void SayHello(string name);
}
```

The Liskov Substitution Principle

```
public interface IT
{
    /// <summary>
    /// Contract: Invoking this method should print a
    /// message on the screen.
    /// The message should
    ///    1) Have a polite greeting nature.
    ///    2) Use the name provided in the argument.
    ///    3) Be in English.
    /// No side effect should occur by calling this method.
    /// </summary>
    void SayHello(string name);
}
```

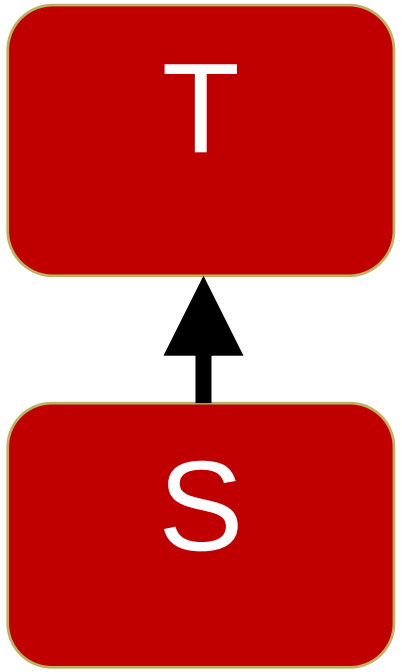
The Liskov Substitution Principle

```
public class CheckedGreeting : T
{
   public override void SayHello(string name)
   {
      if (name.Length < 3)
      {
         throw new ArgumentException("Name too short!");
      }

      base.SayHello(name);
   }
}
```

The Liskov Substitution Principle

- **More detailed definition:**

- *If the class **S** is a subtype of the class **T**, then it must always hold that*
  - ***Preconditions** in **T** are never strengthened by **S**.*
  - ***Postconditions** in **T** are never weakened by **S**.*
  - ***Invariants** in **T** must be preserved by **S**.*



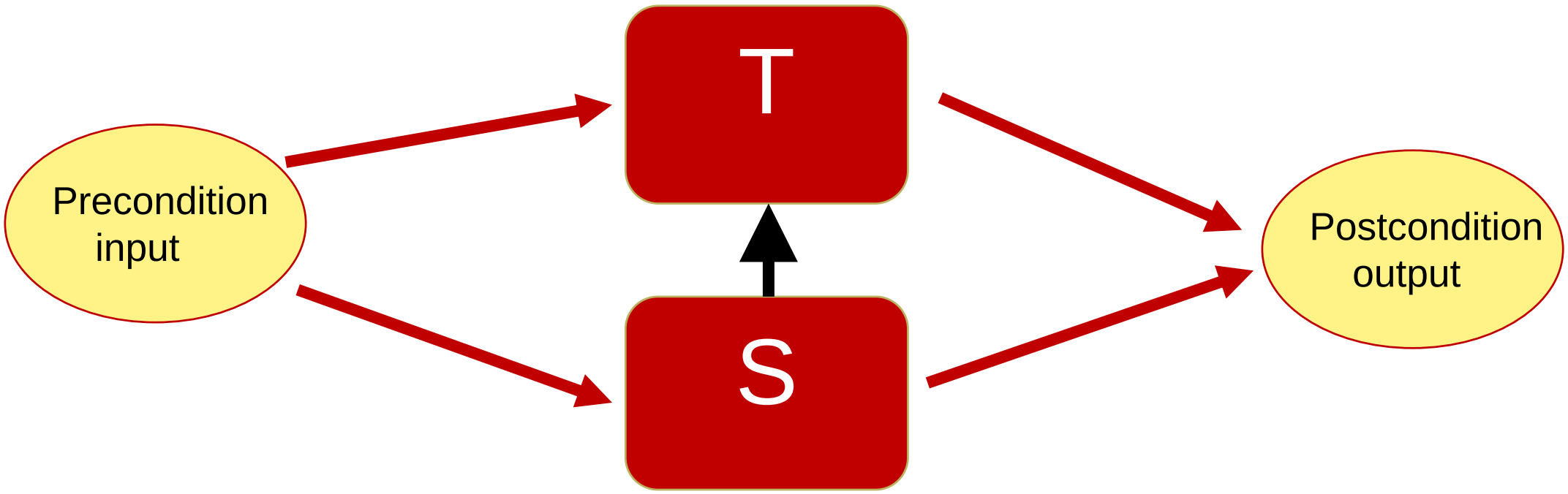
The Liskov Substitution Principle

```
// Precondition was strengthened...
public class CheckedGreeting : T
{
   public override void SayHello(string name)
   {
      if (name.Length < 3)
      {
         throw new ArgumentException("Name too short!");
      }

      base.SayHello(name);
   }
}
```

The Liskov Substitution Principle

```
public class Client
{
   public void DoSomething(T obj)
   {
      obj.SayHello("Alex");
      obj.SayHello("Bo");
   }
}

Client aClient = new Client();
aClient.DoSomething(new T()); // OK
aClient.DoSomething(new CheckedGreeting()); // Oops...
```

The Liskov Substitution Principle

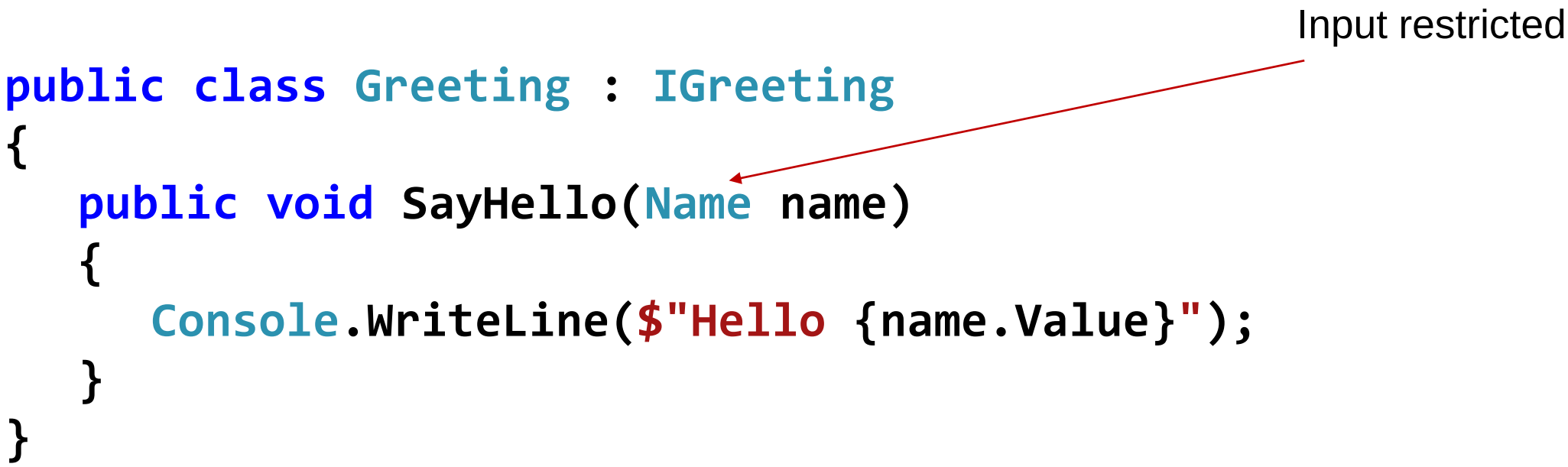


The Liskov Substitution Principle

- Improvement – for precondition

```
public class Name
{
   public string Value { get; }

   public Name(string value)
   {
      if (value.Length < 3) { throw new …}
      Value = value;
   }
}
```

The Liskov Substitution Principle



The Liskov Substitution Principle

- Improvement
  – for postcondition

```
public class Salery
{
   public int Value { get; }

   public Salery(int value)
   {
      if (value < 10000 || 1000000 < value)
         { throw new …}
      Value = value;
   }
}
```

The Liskov Substitution Principle

```
public interface IEmployee
{
   /// <summary>
   /// Contract: the yearly salary returned must
   /// be a value between 10,000 and 1,000,000
   /// </summary>
   Salery GetYearlySalary();
}
```

output restricted

Exercises

- **SOLID 3**
- **SOLID 4**