Contents

1 Patterns

What is a Pattern The GoF had 4 elements for specifying a design pattern. Today you have 6:

Context What is your task, give a little background information
Intent What do you want to solve?
Forces What does it make hard to solve this problem?
Benefits What is positive when implemented?
Liabilities What does it cost you?

Example:

- Context: Design a waiting room
- Intent: efficient use of time
- Forces: different needs of different people
- Benefits: well-being ↑
- Liabilities: Costs

Pattern Language A Pattern Languages combine patterns according to their relationships. If you have established a Pattern Language, you can read a text and just insert the name of the patterns, and it does make sense.

2 GoF

Mediator The Mediator Design Pattern is used to encapsulate how a set of objects interact with each other. The different objects do not have to reference each other explicit.

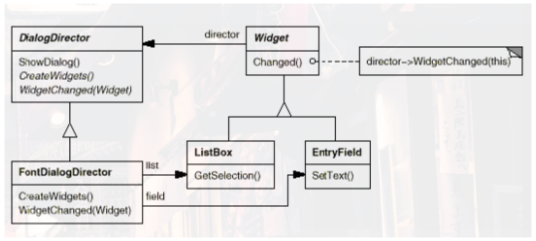


Figure 1: Mediator Class Diagram

1. How does it work? The mediator holds a reference to every object. The user selected some item from the list box (object A). Object A notifies the mediator that the value has changed. The mediator know notifies the other objects.

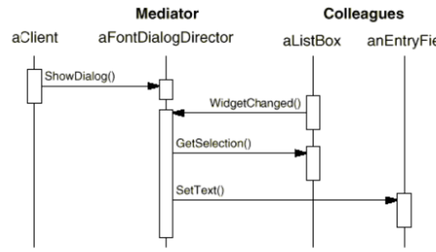


Figure 2: Mediator Sequence Diagram

Memento The Memento Design Pattern is used to store an internal state. This is often used for restoring the internal state of an object.
The object creates a memento (a copy of the state itself) and returns it to the world. The state of the object can be restored using such a memento. You can not change the memento and the inner live is unknown to the outer world.

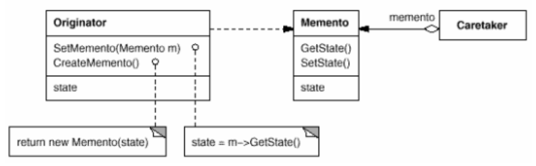


Figure 3: Memento Class Diagram

Command The command pattern is used to encapsulate actions / request inside an object. For example, the design of a framework does not know which action the button should perform. Therefore, the button is created using a command as parameter. As soon as the user clicks on the button, the button executions the `command.Execute()` function.

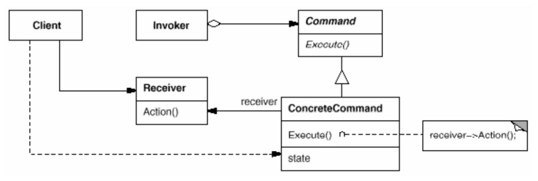


Figure 4: Command Class Diagram

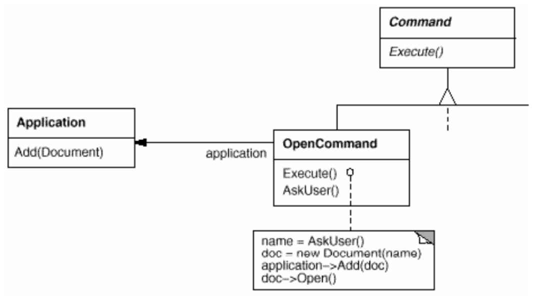


Figure 5: Example of Command Pattern

Command Processor The Command Processor is an extension of the Command Pattern. The Command Processor is more or less just a Stack of Commands.

The Command Processor gets the command (`do_it`). If you want to undo more than one command you just call `undo_it` multiple times on the processor.

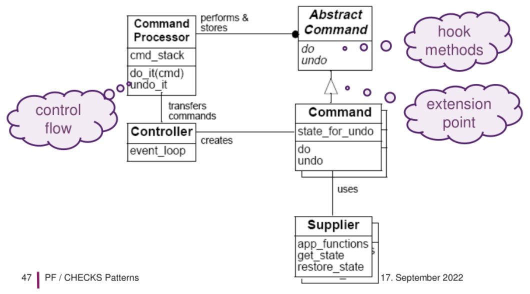


Figure 6: Command Processor

Visitor The Visitor Patter is used to ”visit” class hierarchy. The visitor can perform action on the visited elements (for example spell checking in a document).

It is easy to implement a new Visitor (Just implement the Interface). However, extending the class hierarchy with a new subclass is very difficult. You have to extend the interface `Visitor` and therefore all implementations of this interface.

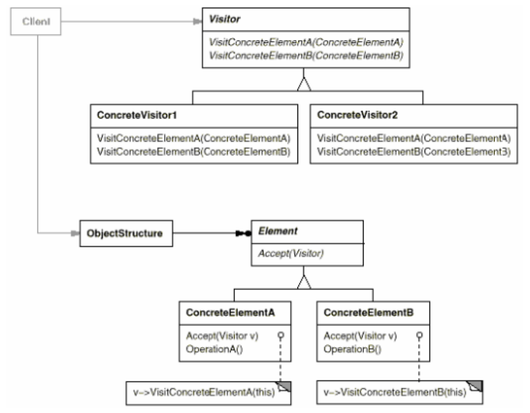

Client
Visitor
VisitConcreteElementA(ConcreteElementA)
VisitConcreteElementB(ConcreteElementB)
ConcreteVisitor1
VisitConcreteElementA(ConcreteElementA)
VisitConcreteElementB(ConcreteElementB)
ConcreteVisitor2
VisitConcreteElementA(ConcreteElementA)
VisitConcreteElementB(ConcreteElement3)
ObjectStructure
Element
Accept(Visitor)
ConcreteElementA
Accept(Visitor v)
OperationA()
ConcreteElementB
Accept(Visitor v)
OperationB()
v->VisitConcreteElementA(this)
v->VisitConcreteElementB(this)

Figure 7: Visitor Class Diagram

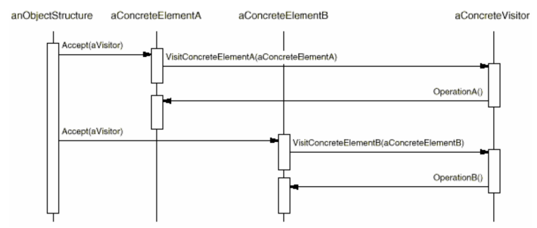


Figure 8: Visitor Sequence

Iterator The iterator design pattern is used to access the items in a Data structure (Aggregate in figure 9). The benefit of iterator is that it hides the implementation details of the data structure.

```
let my_vec = vec![1, 10];
let iter = my_vec.iter();
let _ = iter.next();
let _ = iter.next();
// ...
```

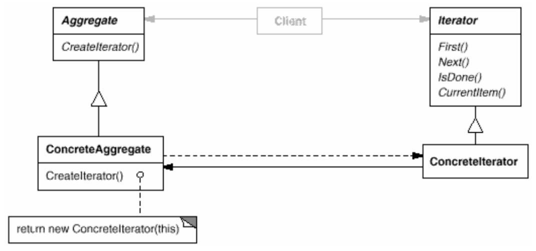


Figure 9: Iterator Class Diagram

State The state pattern is used allow an object to alter its internal behavior depending on its state. The object will appear to change its class.

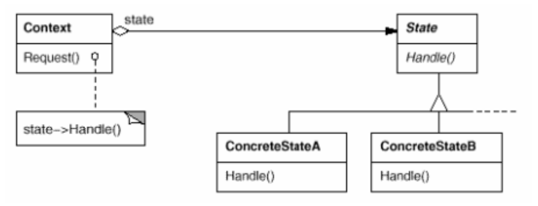


Figure 10: State Class Diagram

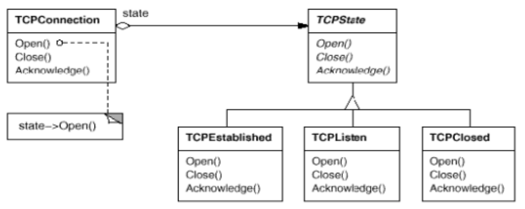


Figure 11: TCP Connection with State

Method for States The Methods for States Pattern is a derivation of the State Pattern by GoF. A State is represented as a collection of functions (struct, HashMap, enum,

...). The State Machine itself stores such a collection of function inside and just executes the function on the struct.

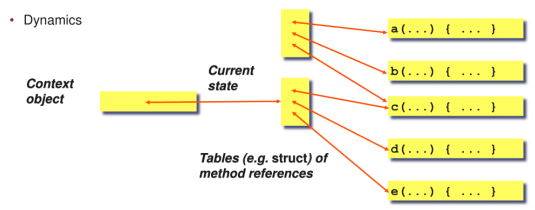


Figure 12: Methods For State Example

Collection for States Collection for States is a way to handle multiple objects in a particular state. For each state you have a list / collection, which contains the objects in this state.
If an event is triggered, then the event is executed on all objects in the list, which should handle this. The distinction between the states is made depending on which list / collection the work item is.

Factory Method The Factory Method is used to create an object, but the subclass decides which class is instantiated. With this pattern you can create concrete creators which can decide which concrete product should be created. The user of the creator only has to use the interface.

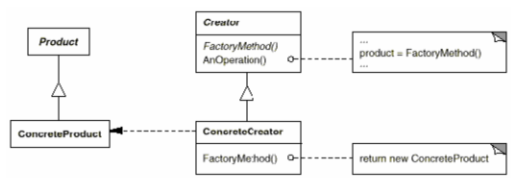


Figure 13: Factory Method Class Diagram

Template Method Using the Template Method Pattern you write the skeleton for an algorithm in the base class. The functions which do something with data can be overwritten in a subclass.

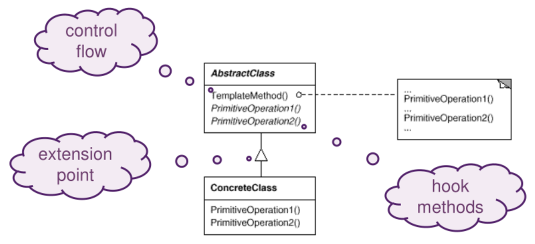


Figure 14: Template Method Class Diagram

1. Example In an algorithm to traverse a tree in order you can implement a function `handleData()`. This function is called every time when the element is "in order". You have now one implementation of the algorithm, but you can handle the data differently using subclasses.

Strategy The Strategy Pattern is used to encapsulate an algorithm in an object. With this approach you can change the algorithm at runtime.

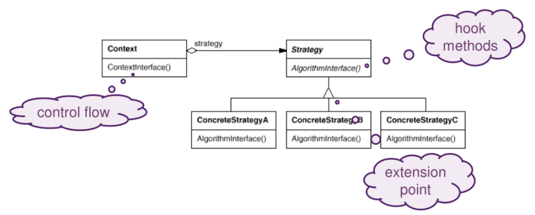


Figure 15: Strategy Class Diagram

Flyweight The Flyweight pattern is used to support large number of objects efficiently. For example, you can store every character in its own object. In a document with 1000 characters you need more than 1000 objects. The Flyweight pattern helps here.
In the Flyweight class is only state indecent stuff stored. Therefore, the Flyweight is shareable. Instead, creating every time a new object with the character "a" you always reference to the same object.

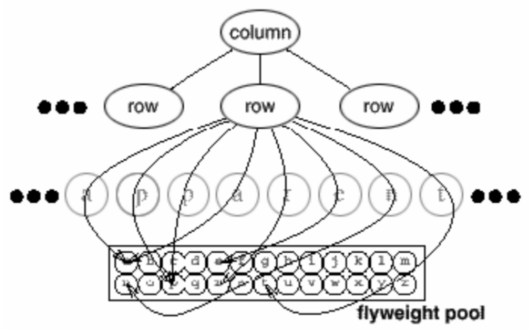
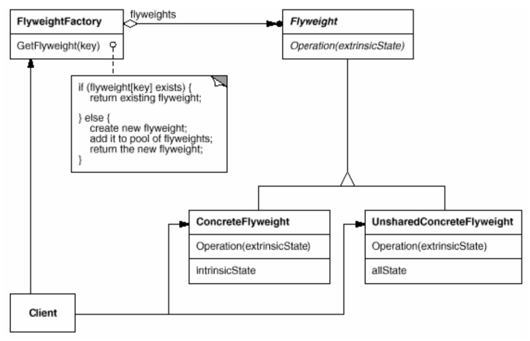


Figure 16: Flyweight Example



FlyweightFactory
GetFlyweight(key)
flyweights
Flyweight
Operation(extrinsicState)
ConcreteFlyweight
Operation(extrinsicState)
intrinsicState
UnsharedConcreteFlyweight
Operation(extrinsicState)
allState
Client

```
if (flyweight[key] exists) {
    return existing flyweight;
} else {
    create new flyweight;
    add it to pool of flyweights;
    return the new flyweight;
}
```

Figure 17: Flyweight Class Diagram

3 Value Patterns

Value Object The Value Object Pattern is used to represent a class as values (immutable). In Java you don't have a Value Type `Year`. Year however, is just a number. With the Value Object Pattern you can simulate the same behavior for the Class `Year` as it was a type `int`. The Identity is **not** important for such a type / value.
In C# just use the `struct` keyword. In Java use the `record` keyword. However, you have to do some more stuff in Java.

> «Override the methods in Object whose action should be related to content and not identity and implement serializable.» [Henney]

```
public final class Date implements
    Serializable {
    // ...
    private static final long
        serialVersionUID =
        -3248069808529497555L;
    // ...
    @Override
    public boolean equals(Object o) {
        if (this == o) return true;
        if (o == null || getClass() != o
            .getClass()) return false;
        Date date = (Date) o;
        return year.equals(date.year) &&
             month.equals(date.month) &&
            day.equals(date.day);
    }
    @Override
    public int hashCode() {
        return Objects.hash(year, month,
            day);
    }
}
```

Whole Value The Whole Value Pattern answers the following question:

> How can you represent primitive quantities from your problem domain without loss of meaning?
>
> «Express the type of the quantity as a Value Class.» [Henney]

The Whole Value can be immutable, but it is not required to be.

```
public final class Year {
    public Year(int year) { value = year
        ; }
    public int getValue() { return value
        ; }
    private final int value;
}

public final class Date {
    public Date(Year year, Month month,
        Day day) { /**/ }
    /**/
}
Date first = new Date(new Year(year),
    new Month(month), new Day(day));
```

Enumeration Value An enumeration value is just an Enum in Java, C# or Rust.

Immutable Value An Immutable Value can not be changed. That means all internal fields are `const` or `final`.

```
struct Value {
    readonly int _value;
}
```

Simple Factory Intent:

- Provide an interface for creating objects without specifying the concrete implementation.

Motivation:

- You want to create concrete objects without knowing which concrete type you get.
- You are only interested in the interface.

Mutable Companion

> How can you simplify complex construction of an Immutable Value?

A Mutable Companion is a factory object for immutable values. `StringBuilder` is an example for such a Mutable Companion for `Strings`. For the final creation of the object (see Listing 1) you use the Design Pattern - Factory Method.

```
var yearBuilder = new YearCompanion(Year
    .of(2020));
yearBuilder.next();
var nextYear = yearBuilder.asValue();

public final class YearCompanion {
    private int value;

    public YearCompanion(Year toModify)
        {
        this.value = toModify.getValue()
            ;
    }
    public void next() {
        this.value++;
    }
    public Year asValue() { // factory
        method
        return Year.of(value);
    }
}
```

Listing 1: Example for Mutable Companion

4 CHECKS Patterns

Exceptional Behavior

> How can exceptional behavior caused by invalid input be handled without throwing errors?

If your function should indicate an error, but should not throw an error / exception then return an *exceptional value* in an error case. An *exceptional value* could be:

- `null` or `undefined` (not recommended)
- Enumeration Value to identify what went wrong

```
export enum CalculationError {
    DivByZero = "div/0",
    NumeratorIsNaN = "NaN(numerator)",
    DivisorIsNaN = "NaN(divisor)"
}

export class Calculator {
    public static divide(numerator:
        number, divisor: number): number
        | CalculationError {
        if (divisor === 0) {return
            CalculationError.DivByZero; }
        if (isNaN(numerator)) {return
            CalculationError.
            NumertorIsNaN; }
        if (isNaN(divisor)) {return
            CalculationError.DivisorIsNaN
            ; }
        return numerator / divisor;
    }
}
```

Meaningless Behavior

> Write methods (without) with minimalistic concern for possible failure.

You will return a meaningless value unless a condition has domain meaning

5 Framework

Framework A framework is a collection of classes, functions, ... that are working together. A framework provides *hook* for *extensions*. In contrast to a library is, that the framework own the control flow and calls **your** components (Inversion of Control).
Examples:

- Java
  - Hibernate
  - Velocity
- C#
  - .NET / Core
  - Entity Framework
- JS
  - Vue.js

Application Framework An Application Framework is a special kind of framework. In a framework you use the framework, and you start the framework. In an Application Framework the "main" method lives inside the application framework.
An example for an Application Framework is Eclipse. Based on the Eclipse you can create many other products (Java IDE, C++ IDE, ...).
Examples:

- Java
  - Spring (Boot)
  - Application Server (J2EE)
- C#
  - ASP.NT
- JS
  - Angular

6 Reflection

Reflection Reflection consists of two aspects:

- *Introspection* (observe own state, e.g. query object properties)
- *Intercession* (modify own state, e.g. add another attribute)

> In computer science, reflective programming or reflection is the ability of a process to examine, introspect, and modify its own structure and behavior. [Wikipedia]

```
if (origin instanceof Cloneable) {
    cloned = ((Cloneable)origin).clone()
        ;
} else {
    cloned = origin.getClass().
        getDeclaredConstructor().
        newInstance();
    // ...
    BeanUtils.copyProperties(origin,
        cloned); // get data from getters
        , fill into setters.
}
```

Meta Level Programming The *Meta Level* provides a self-representaiton

- gives the software knowledge of its own structure
- consists of Meta Objects
- interface for manipulation meta objects is called Metaobject Protocol

The *base level* defines the application logic.

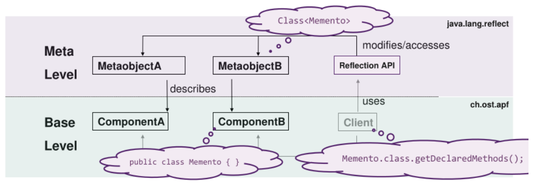


Figure 18: Meta Level and Base Level

Meta Object If a programming language uses reflections it uses meta objects for:

- classes
- object attributes
- methods
- class relationships
- ...

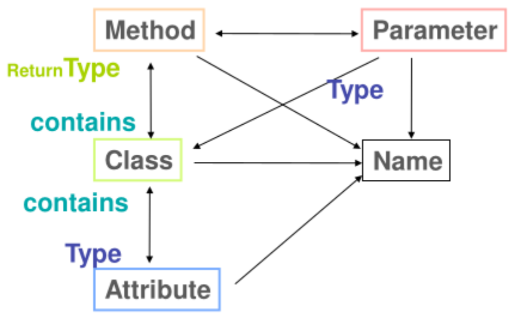


Figure 19: Meta Object class relations

Meta Object Protocol The Metaobject protocol provides a vocabulary to access and manipulate the structure and behavior of a system of objects.

Pro / Con Reflection Benefits:

- Adapting a software system is easy
- support for many kinds of changes

Liabilities:

- Produces non-transparent APIs
  - control flow already hard to understand with polymorphism
- binding at runtime (late binding)
  - limited type safety (Rename class, but class name in string during reflection class is not renamed)
  - lower efficiency, no compiler-optimizaiton

Type Object A Rental System contains books and videos. For each book / video multiple copies may exist. The descriptive information (title, author, actors) is stored in the book / video class (shared among copies). Each media item type has own data and behavior.

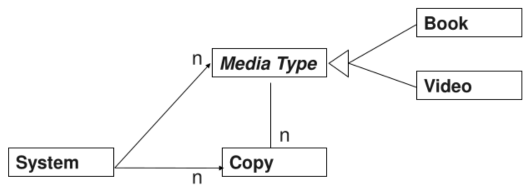


Figure 20: Rental System Example

Problem:

- We want to keep common behavior and data in only one place
  - object behavior depends on category (video / book)
  - categories should be objects themselves

  How can you categorize objects, eventually dynamically?

  Categorize objects by another object instead of a class (Book, Video) Thus, an object can change 'class' at runtime.

Solution:

- crate a category (*type*) object which describes multiple objects
- *objects* forward the calls to the underlying type

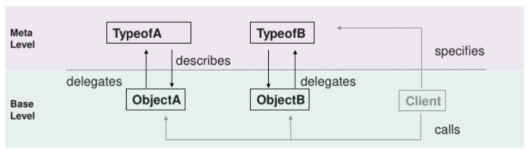


Figure 21: Meta / Base Level Interactions

```
// Base level
public class Copy {
    protected MediaType type;
    protected int copyid; // invoentory
        no

    public int getId() { return copyid;
        }
    // example for delegation
    public String getTypeid() { return
        type.getId(); }
    public String getTitle() { return
        type.getTitle() ;}
}

// Meta level
public class MediaType {
    protected String title;
    protected String typeid;

    public String getId() { return
        typeid; }
    public String getTitle() { return
        title; }
}
```

Property List **Problem**:

- attributes should be attachable / detachable after compilation
- objects share attributes / parameters across the class hierarchy

  How do you define properties (also arguments) in a flexible way, so they can be attached and detached at runtime?

  Provide objects with a 'property list'. That list allows to associate names with other values or objects.

Solution:

- property list maps attribute names to values
- each name (e.g. a string) defines a slot / property

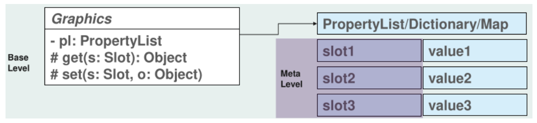


Figure 22: Property List Example

```
public class Graphics {
    private Properties pl;

    public String get(String prop) {
        return pl.getProperty(prop, "");
    }
    public void set(String prop, Object
        value) {
        pl.setProperty(prop, value);
    }
}

package java.util;
public class Properties {
    public Set<String>
        stringPropertyNames() { /**/ }
    public String getProperty(String
        prop, String defaultValue) { /**/
        }
    public String setProperty(String
        prop, Object value) { /**/ }
}
```

Benefits:

- you can extend the object with properties at runtime while keeping object identity

Liabilities:

- Type safety left to the programmer (see Design Pattern - Bridge Method)
- naming not checked by a compiler (see Design Pattern - Bridge Method)

Anything The Anything Pattern can be used to describe / create arbitrary data structure. The Anything Pattern is something like a recursively structured Property List (Design Pattern - Property List)
An object is a collection of properties (property list) where you access the different values by name / key. An array is a collection of properties (property list) where you access the different values by index.

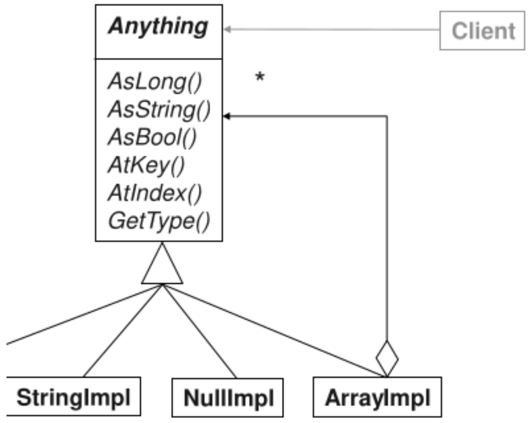


Figure 23: Anything Class Diagram

7 Singleton

Singleton The Singleton pattern ensures that a class has only one (global) instance. Additionally, it provides easy access to this element.
However, you should **NOT** use it in your software. It is basically a global variable. Therefore, not testable and difficult to maintain.
If you want something like singleton, you should use a simple factory which always returns the same instance.

```
class SingletonFactory {
    private static object myInstance;

    createObject() {
        if (SingletonFactory.myInstance
            == null) {
            SingletonFactory.myInstance
                = new();
        }
        return SingletonFactory.
            myInstance;
    }
}
```

Listing 2: Singelton alternative in code

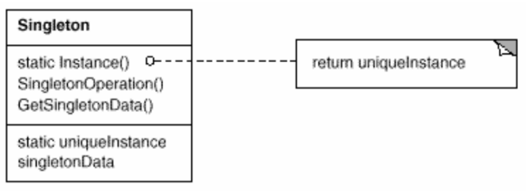


Figure 24: Singelton Class Diagram

Registry The Singleton Design Pattern is evil and should not be used. An alternative could be the Registry pattern.
You will register multiple singletons in the registry. Using a `lookup(name)` function you will get your specific singleton. The `instance()` returns the default singleton from the registry.

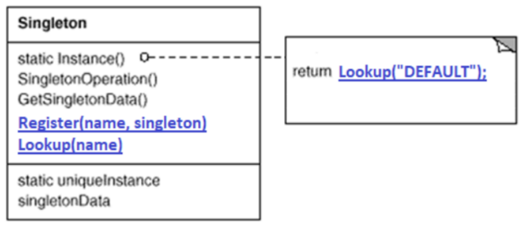


Figure 25: Registry UML

Monostate If you have to use a framework, which provides a singleton you can kill this singleton using a *Monostate*. A monostate is a normal class, **but** all member variables are static members (see Listing 3 and Listing 4).
Attention: In parallel and async execution you have to sync the access to static members.

```
public class Monostate {
    private static int x;
    private static int y;

    public int getX() { return x; }
    public int getY() { return y; }
}
```

Listing 3: Example for a simple monostate

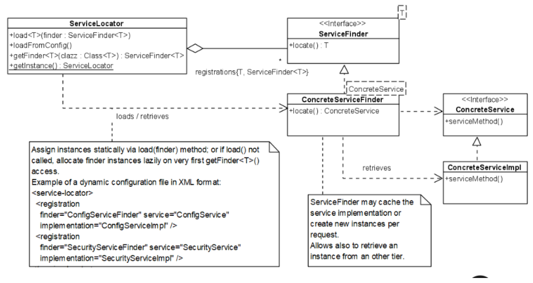
```
public interface Monostate {
    int getX();
    int getY();
}

public class MonostateImpl implements
    Monostate {
    public int getX() {
        return Singleton.getInstance().
            getX();
    }

    public int getY() {
        return Singleton.getInstance().
            getY();
    }
}
```

Listing 4: Kill a singleton

Service Locator The Service Locator is a singleton, which only returns services or finders to find the concrete service. The Service Locator is similar to a Registry. If you use the Service Locator you have only **one** singleton in your application.

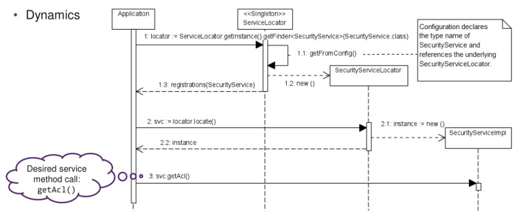


Assign instances statically via load(finder) method; or if load() not called, allocate finder instances lazily on very first getFinder<T>() access.
Example of a dynamic configuration file in XML format:

```
<service-locator>
  <registration
    finder="ConfigServiceFinder" service="ConfigService"
    implementation="ConfigServiceImpl" />
  <registration
    finder="SecurityServiceFinder" service="SecurityService"
    implementation="SecurityServiceImpl" />
```

ServiceFinder may cache the service implementation or create new instances per request.
Allows also to retrieve an instance from an other tier.

Figure 26: Service Locator UML


Dynamics
Application
<<Singleton>>
ServiceLocator
1: locator := ServiceLocator.getInstance().getFinder<SecurityService>(SecurityService.class)
1.1: getFromConfig()
SecurityServiceLocator
1.2: new ()
1.3: registrations{SecurityService}
2: svc := locator.locate()
2.1: instance := new ()
SecurityServiceImpl
2.2: instance
3: svc.getAcl()
Desired service method call: getAcl()

Configuration declares the type name of SecurityService and references the underlying SecurityServiceLocator.

Figure 27: Service Locator Dynamics

Parameterize from Above Often you have functionality which should be shared over multiple or all layers (configuration, security). To solve this problem, without creating a singleton you can use *Parameterize from Above*. In the main method you will create all services. And you provide all services over the constructor (form above, see Listing 5).

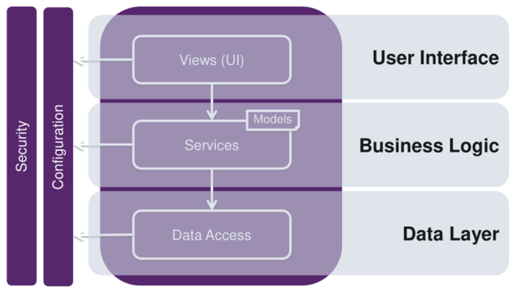


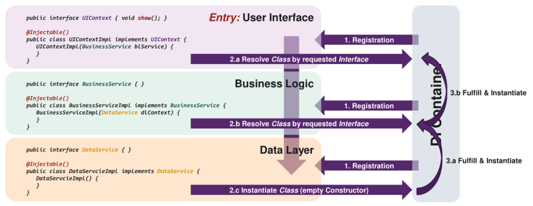
Figure 28: Horizontal and vertical layering

```
public final class Bootstrapper {
    public static void main(string[]
        args) { // PfA applied
        // instantiate vertical layer
            contexts first
        SecurityContext securityContext
            = new SecurityContextImpl();
        ConfigurationSettings
            configuration = new
            ConfigurationSettingsImpl(
            args);
        // encapsulate variables into an
            application context
        var applicationContext = new
            ApplicationContextImpl(
            securityContext
            ,
            configuration
            )
            ;

        // instantiate horizontal layer
            contexts from bottom to top
        DataContext dlContext = new
            DataContextImpl(
            applicationContext);
        BusinessContext blContext = new
            BusinessContextImpl(
            applicationContext, dlContext
            );
        UIContext uiContext = new
            UIContextImpl(
            applicationContext, blContext
            );
        // show initial UI dialog
        uiContext.show();
    }
}
```

Listing 5: Example for Parameteriz from Above

Dependency Injection A Dependency Injection Container is used to store all services in a registry and injects the required services in the constructor while creating (Parameterize from Above).
You register all services and components in the container. The container will inject a compatible component according to your function signature.


```
public interface UIContext { void show(); }

@Injectable()
public class UIContextImpl implements UIContext {
   UIContextImpl(BusinessService blService) {
   }
}

public interface BusinessService { }

@Injectable()
public class BusinessServiceImpl implements BusinessService {
   BusinessServiceImpl(DataService dlContext) {
   }
}

public interface DataService { }

@Injectable()
public class DataServcieImpl implements DataService {
   DataServcieImpl() {
   }
}
```
Entry: User Interface
Business Logic
Data Layer
1. Registration
2.a Resolve Class by requested Interface
1. Registration
2.b Resolve Class by requested Interface
1. Registration
2.c Instantiate Class (empty Constructor)
DI Containe
3.b Fulfill & Instantiate
3.a Fulfill & Instantiate

Figure 29: Dependency Injection Example

8 END