# UCLA CS130 Software Engineering Fall21 Review Note: Midterm

By Patricia Xiao

## UML Diagrams

Static / Structure Modeling: fixed, code-level

- Class Diagrams
- etc. (e.g. Component Diagrams)

Dynamic / Behavioral Modeling: capturing execution of the system

- Use Case Diagrams
- Sequence Diagrams
- State Chart Diagrams
- etc. (e.g. Activity Diagrams)

## Class Diagrams

Models: high-level class relations
Components:

- Class (rectangle)
  - Upper section: name of the class
  - Middle section: attributes (type, visibility)
  - Bottom section: methods (type, visibility)
- Relations (links between classes): Dependency, Association, Aggregation, Composition, Generalization, Realization

## Class Diagram: Visibility Symbols

| | | |
|---|---|---|
| Public (+) | Private (−) | Protected (#) |
| Package (∼) | Derived (/) | Static (underlined) |

## Class Diagram: Multiplicity Definition

Multiplicity (Cardinality)
Of a **class**: A number in the upper right corner of the component; the number of objects at runtime; usually omitted and by default $> 1$.
Of a **relation**: Placed near the ends of an edge, indicating the number of instances of one class linked to an instance of the other class on the other side of the edge.

## Class Diagram: Multiplicity Symbols

| $n$ | exactly $n$ | $m..n$ | at least $m$, at most $n$ |
|---|---|---|---|
| $*$ | many | $1..*$ | at least one, could be more |
| 0..1 | zero or one | 0..0 | must be empty |

## Class Diagram: Relations

From weak to strong, from general to specific:

- Dependency (uses) — A uses B (dashed line pointing from A to B)
- Association (has-a) — A has a field of B object (solid line pointing from A to B)
- Aggregation (owns) — satisfies iff
  - A has a field that is a list of B objects

  (solid line pointing to B with an **unfilled** diamond at the A end / association end)
- Composition (part-of) — satisfies iff
  - A has a field that is a list of B objects
  - B object can't live outside A

  (solid line pointing to B with an **filled** diamond at the A end / association end)
- Generalization (is-a) — B extends A / sub-classing (close-headed solid line pointing to A)
- Realization — B implements A / sub-typing (close-headed dashed line pointing to A)

## Use Case Diagram

Specify: Actors, System (scenario), Goals
Models: high-level **interactions**
Components:

- Actors (stick figures) – role (one user can have multiple roles)
- Use Cases (ovals) – scenario
- Relations (edges): association, inclusion, extension, generalization

Actors are **not** directly interacting with each other.

## Use Case Diagram: Relations

Association

- actor – case (undirected solid line)
- case – case (dashed line with arrow)
  - inclusion (e.g. *ride* ≪ include ≫ *push button*, arrow pointing to *push button*)
  - extension – exceptional variation (e.g. *derail* is an ≪ exception ≫ of *ride*, arrow pointing to *ride*)

Generalization/Specialization (close-headed arrow pointing to more general one); e.g. *Synchronize Data* generalize *Synchronize Data Wirelessly*

## Sequence Diagram

Models: **communication** between elements
Belongs to **Interaction** Diagrams (include: Sequence diagrams, Communication diagrams, Interaction overview diagrams, Timing diagrams)
Components:

- Class Roles / Participants (top-row) / Actors
  - instance_name : Class_Type
  - not necessarily an object in the system, e.g. can be human actors.
- Activation or Execution Occurrence (dispatch: solid black dot, destroy ≪ destroy ≫)
- Messages (horizontal arrows)
  - Method Invocation (solid line with arrow)
  - e.g. a:A point to b:B with text execute(0), then it means a (of class A) calls b.execute(0), b is of class B.
  - Return value via dashed line pointing back
- Lifelines (dashed vertical lines)
  - Invocation Lifetime: vertical rectangles
  - can be nested across actors, and threads within a single actor
- **Loop** (while / for, [condition]) / **Alt** (if-then-else, [if-condition] – horizontal dashed line – [else]) / **Opt** (if-then, [if-condition]) / Par / Region; All shown as wrapped in a rectangle.

## Seq Diagram: Invocation Lifetime v.s. Lifetime

When a:A create an instance of b:B at run time, we draw the rectangle with text content b:B **at the height** where a:A invokes it.
Then it starts to live. When a:A create an instance of B named b, we depict it by letting a:A pointing to a newly-created b:B column via dashed line and text: create(params); where params are the parameters needed for instantiate an object of class B.
**Invocation Lifetime** is not **Lifetime**.
Lifetime is represented by the dashed line, invocation lifetime is represented by the thin vertical rectangle along the dashed line.

## Seq Diagram: Class Name and Type

If name of an object of class A is unknown, it is okay to leave it blank, e.g. : A.

## State Chart Diagram

Models: high-level **state behaviors** of objects
Components:

- Initial State (black filled circle) – start
- Transition (solid arrow)
  - *trigger [guard] / effect*
  - *trigger* if *guard*, make *effect*
  - e.g. Somewhere is a Door's State Machine: *use key [door locked] / [door → unlock]*
- State (rounded rectangle) – of object
- Fork (rounded solid rectangular bar) – 1 incoming arrow, $n$ outgoing arrows; represent splitting into concurrent states.
- Join (rounded solid rectangular bar) – $n$ incoming arrows from the joining states, $m$ outgoing arrow towards the common goal states; multiple states concurrently converge into one on the occurrence of an event or events.
- Self transition (solid line w. arrow pointing back to itself) – the state of the object does not change upon the occurrence of an event
- Composite State (rounded rectangle) – wrapping around a lot of other states
- Final state (black filled circle within a circle) – the final state in a state machine diagram

## UML Diagram: Translations

| format | Class | UC | Seq | State | Code |
|---|---|---|---|---|---|
| Class | N/A | ✗ | ✗ | ✗ | ✓ |
| UC | ✗ | N/A | ✗ | ✗ | ✗ |
| Seq | ✗ | ✗ | N/A | ✗ | ✓ |
| State | ✗ | ● | ✗ | N/A | ● |
| Code | ✓ | ● | ✓ | ✓ | N/A |

UC represents Use Case Diagram, Seq represents Sequence Diagram. Code refers to Java-style pseudo code. The meaning of the marks are listed below:

| | |
|---|---|
| ✓ | sufficient (for the row) to transform to (the column) |
| ● | transformation (from row to column) is doable but needs some extra clarification |
| ✗ | very unlikely to directly transform (the row) to (the column) |

## Software Design Principles

- **Information Hiding** (IH)
- Low Coupling (LC): Reduce the dependencies between modules (classes, packages, etc)
- High Cohesion (HC): A module contain functions that logically belong together.
- Separation of Concerns (SoC): a single concern is easily separated from the rest of concerns.
- etc. (e.g. Law of Demeter (LoD), Abstraction, Liskov Substitution Principle, ...)

There are many different principles. In this class we focus on information hiding.

## Modularization

- Decomposition of a software system into multiple independent modules.
- Easy to interpret & maintain & code-reuse, etc.

## Parnas' Information Hiding (IH) Principle

- A principle for breaking program into **modules**.
- API should (1) only contain design decisions unlikely to change (2) do not reveal any volatile information.
- Makes anticipated changes affect modules in an isolated and independent way.

## Information Hiding (IH) Principle: Conclusion

Information hiding principle is:

- an analysis of how changes will affect existing code
- and assessment of changeability.

## Modularization: Practice

Identify the Modules': **name**, **role**, **input**, **output**.
Changeability Assessment: for **different scenarios**, which module / which module's API(s) need to be changed.
Code Critique:

1. What information is hidden (by XXX Module)?
2. Changes you anticipate? (any new features you may want for the system)
3. Readability and comprehensibility? (e.g. consistent arguments, self-explanatory coding, etc.)
4. Capability to support independent work assignment? (low coupling)

## Modularization: Different Ways to Achieve

Functional decomposition (Flowchart approach)

- Each module corresponds to each step in a flow chart.

Information Hiding (IH)

- Each module corresponds to a design decision that are likely to change and that must be hidden from other modules.
- Interfaces definitions were chosen to reveal as little as possible.

## Design Patterns: Categories

Creational Design Pattern

- **Factory Method**: defines an interface for creating an object but lets subclasses decide which class to instantiate; lets a class defer instantiation to subclasses.
- **Abstract Factory**: provides an interface for creating families of related or dependent objects without specifying their concrete classes.
- **Singleton**: ensures a single object creation, and it must be globally accessible.
- etc. (e.g. Prototype)

Structural Design Pattern

- **Adaptor**: adapts legacy code to a target interface.
- **Façade**: simplifies complex interfaces of multiple subsystems.
- **Flyweight**: share common resources by separating usage contexts from used objects.
- etc. (e.g. Composite)

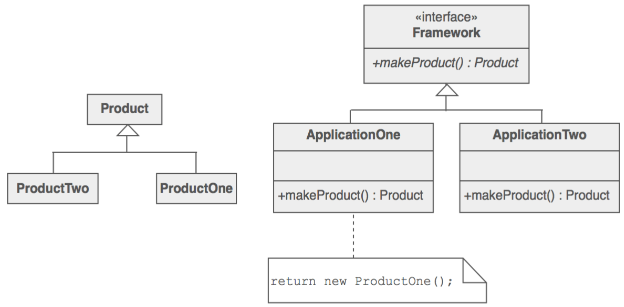
Behavioral Design Pattern

- **Strategy**: defines a family of algorithms, encapsulates each one, and makes them interchangeable at runtime; lets the algorithm vary independently from clients that use it.
- **Observer**: defines one-to-many dependency between objects, when the subject changes state, all of its observers are notified and updated.
- **Mediator**: defines an object that encapsulates how a set of objects interact, encapsulates many to many dependencies between objects, centralizing control logic, reduces the variety of messages.
- **Command**: decouples a receiver object's actions from invokers.
- **Template Method**: set a common workflow where sub steps may vary at subclass.
- **State**: encode complex state transitions.
- etc. (e.g. Interpreter)

## Design Patterns: References

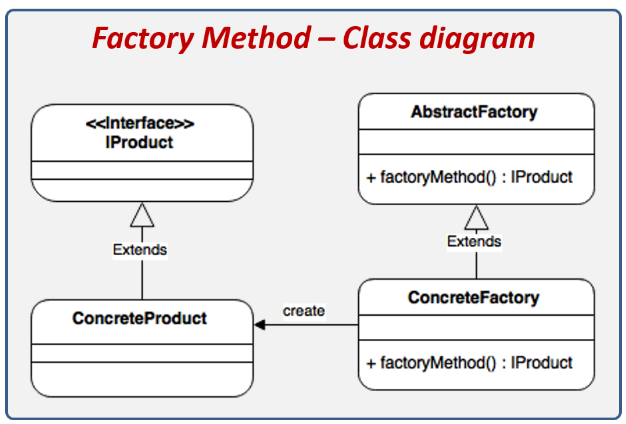
- Book: Head First Design Patterns
- SourceMaking: https://sourcemaking.com/design_patterns/
- ReactiveProgramming: https://reactiveprogramming.io/blog/en/design-patterns/factory-method
- Refactoring.Guru: https://refactoring.guru/design-patterns

## Factory Method Pattern

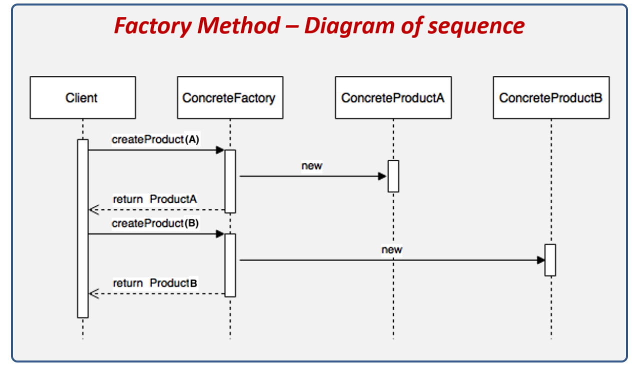



- Factory / Creator: include a factory method
- Concrete Factories / Concrete Creators: implement factory method
- Product
- Concrete Products

## Factory Method: Class Diagram Draft

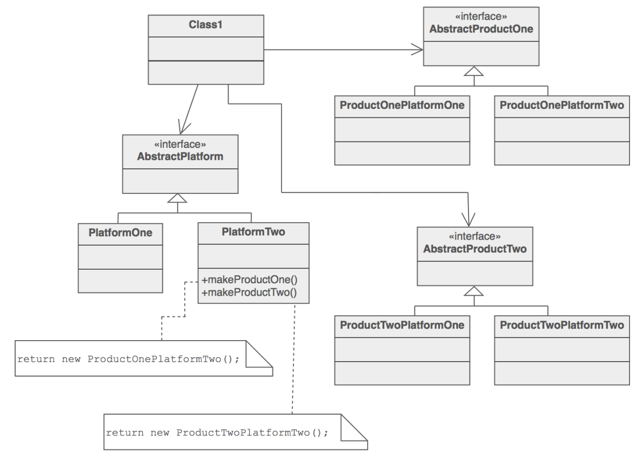



## Factory Method: Sequence Diagram Draft




- **Not** an accurate Sequence Diagram.

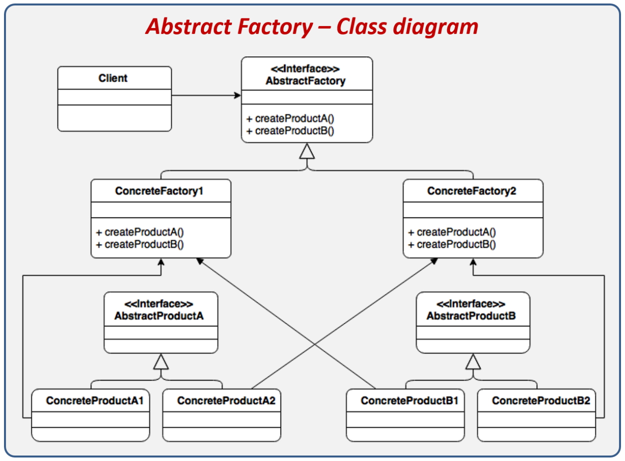
## Abstract Factory Pattern



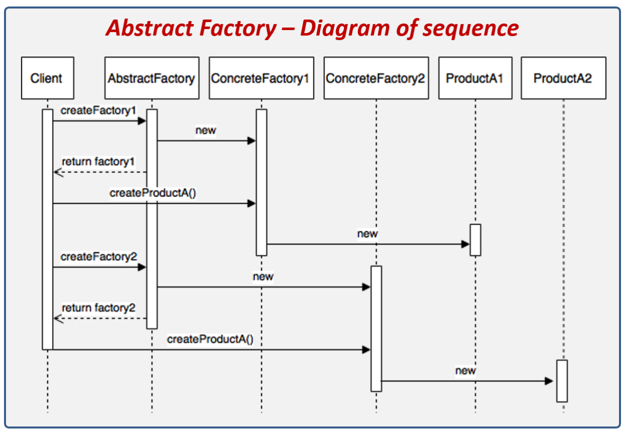

- Abstract Factory / Abstract Creator: include makeProductOne, makeProductTwo, etc.
- Concrete Factories / Concrete Creators: implement factory method
- ProductOne, ProductTwo, etc.
- Concrete ProductOneA, Concrete ProductOneB; Concrete ProductTwoA, etc.

When adding new products to the abstract factory, the interface has to be changed.

## Abstract Factory: Class Diagram Draft

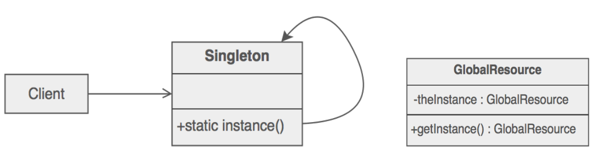



## Abstract Factory: Sequence Diagram Draft



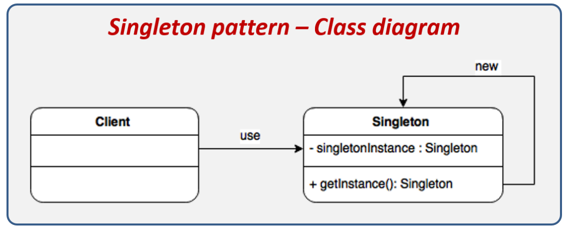

- **Not** an accurate Sequence Diagram.

## Singleton Pattern

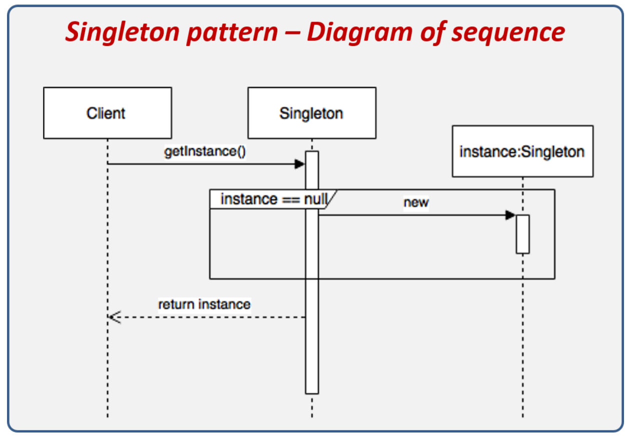



- The class of the single instance is responsible for access and "initialization on first use". The single instance is a private static attribute, accessed via a public static method.

## Singleton: Class Diagram Draft

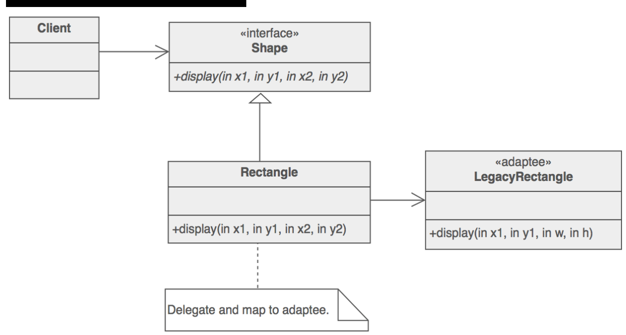



## Singleton: Sequence Diagram Draft



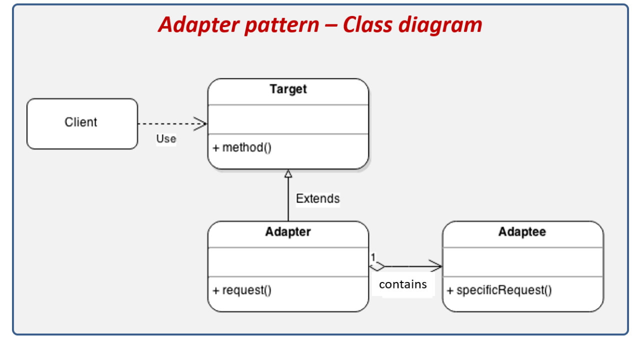

- **Not** an accurate Sequence Diagram.

## Adapter Pattern

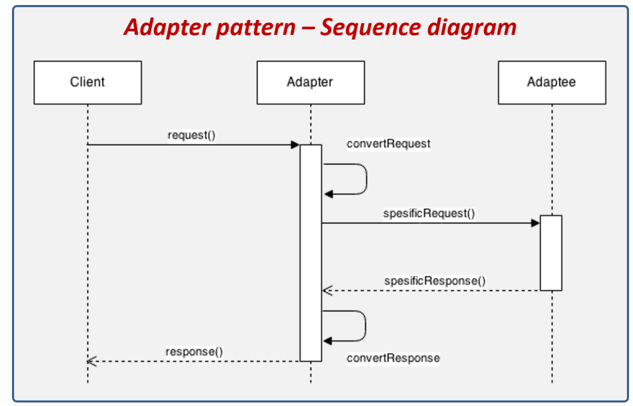



- Adapter: represents the implementation of the Target, hide details of Adaptee; e.g. Rectangle
- Adaptee: represents the class with the incompatible interface; e.g. LegacyRectangle
- Target: e.g. Shape

## Adapter: Class Diagram Draft

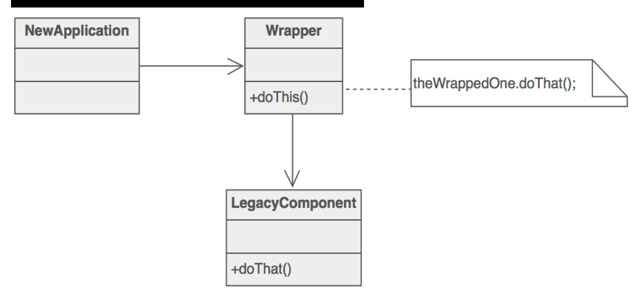



## Adapter: Sequence Diagram Draft

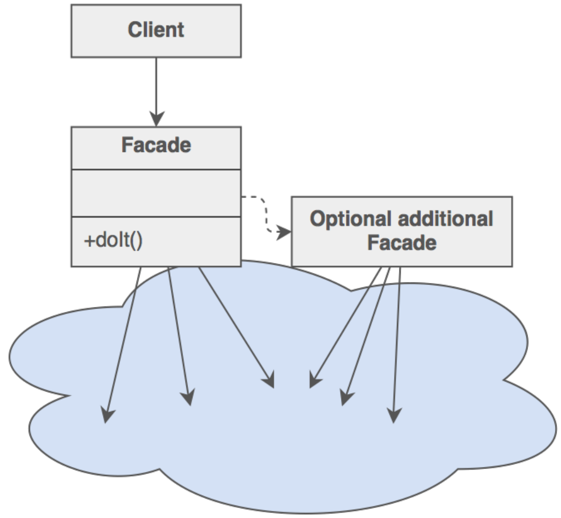



- **Not** an accurate Sequence Diagram.

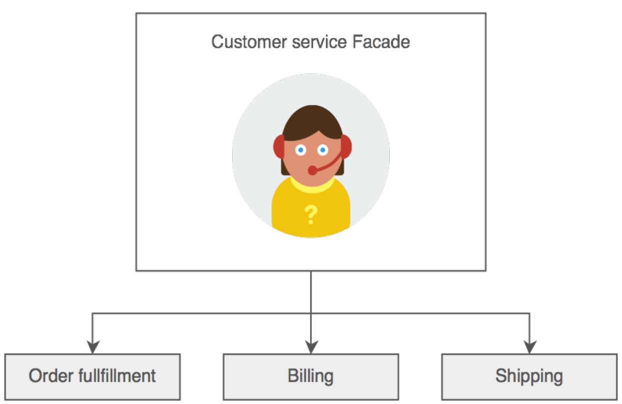
## Adapter: a.k.a. Wrapper



## Façade Pattern

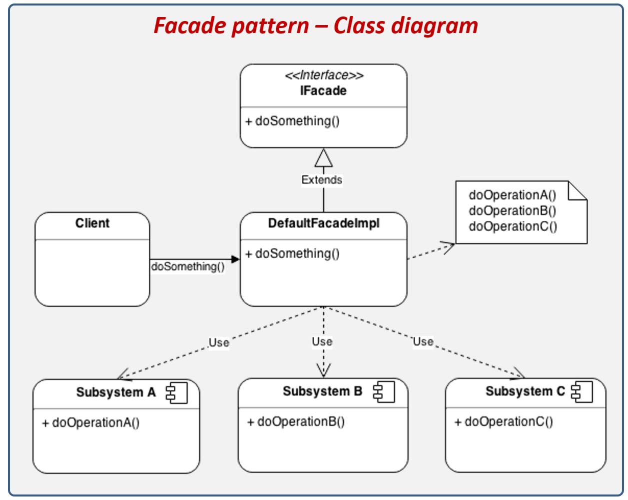



- The Façade defines a unified, higher level interface to a subsystem that makes it easier to use.
- IFacade: high-level interface, hiding the complexity of interacting with multiple systems.
- DefaultFacadeImpl: implementation of IFacade, in charge of communicating with all the subsystems.
- Subsystems: represents all the modules or subsystems with interfaces for communication.

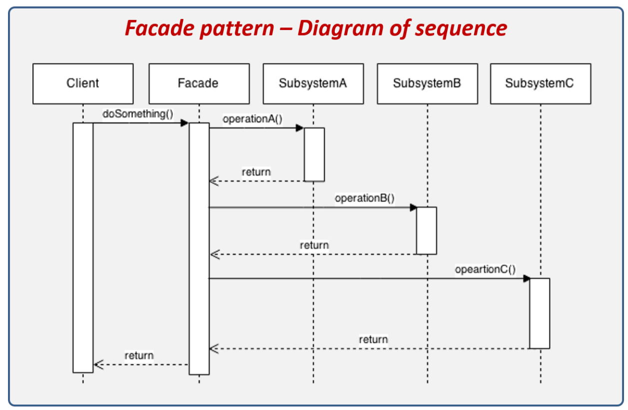



- As an example, the customer-service system could be incredibly complex without Façade.

## Façade: Class Diagram Draft

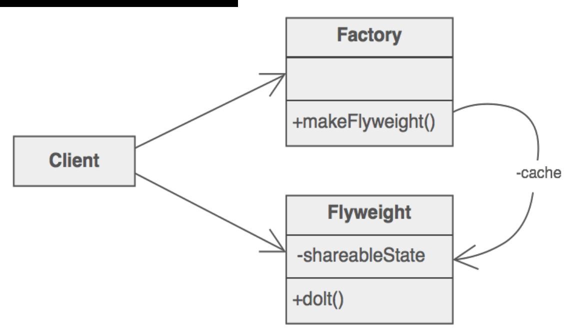



## Façade: Sequence Diagram Draft




- **Not** an accurate Sequence Diagram.

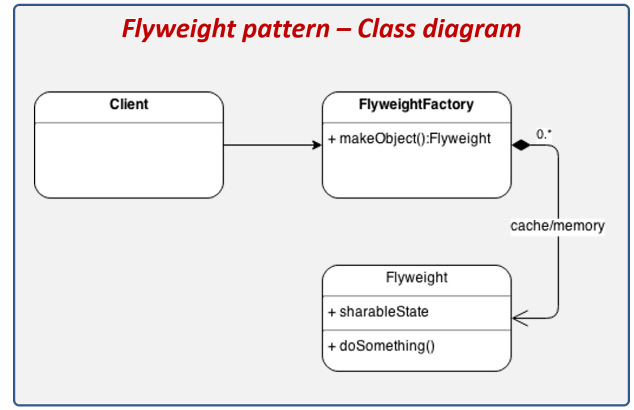
## Flyweight Pattern



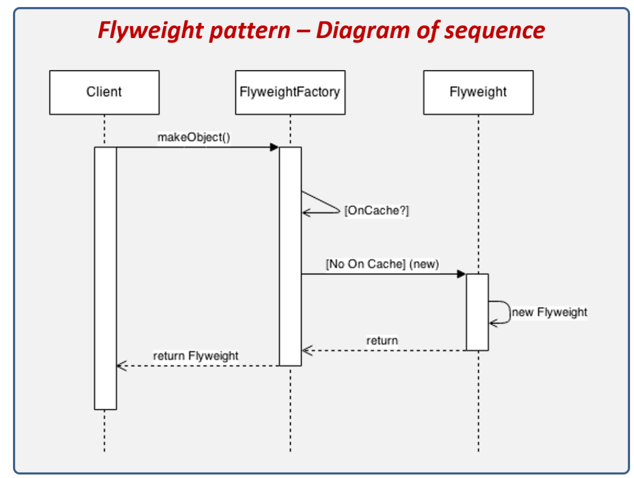

## Flyweight Pattern

- FlyweightFactory: factory class for building the Flyweight objects.
- Flyweight: the objects we want to reuse in order to create lighter objects.

## Flyweight: Class Diagram Draft

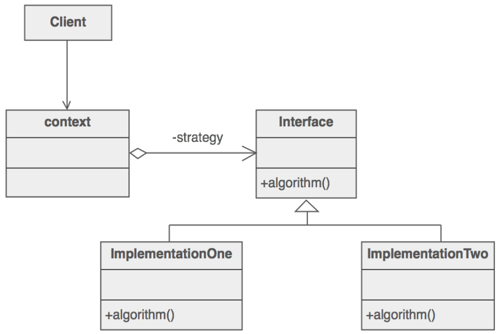



## Flyweight: Sequence Diagram Draft



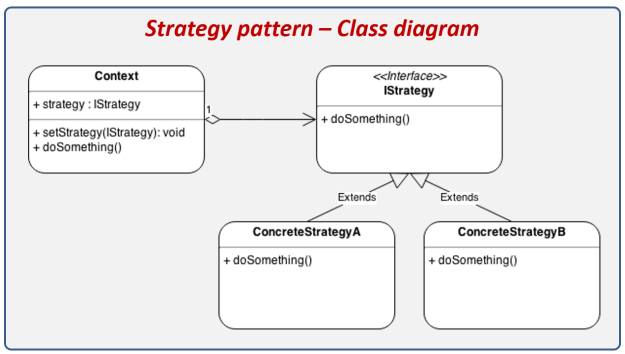

- **Not** an accurate Sequence Diagram.

## Strategy Pattern

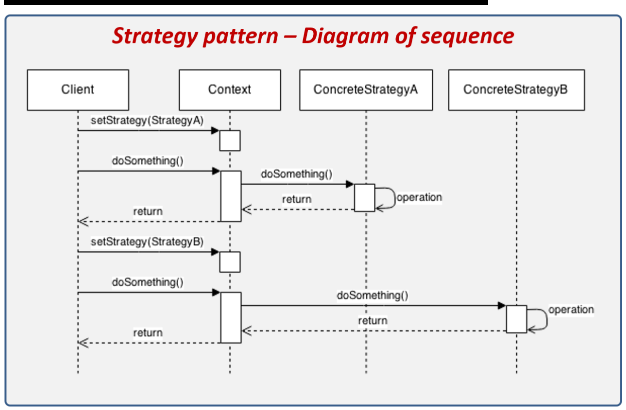



- Strategy Interface: define the common interface of all strategies that must implement.
- Concrete Strategy: inherit from Strategy Interface, they implement concrete strategies.

## Strategy: Class Diagram Draft

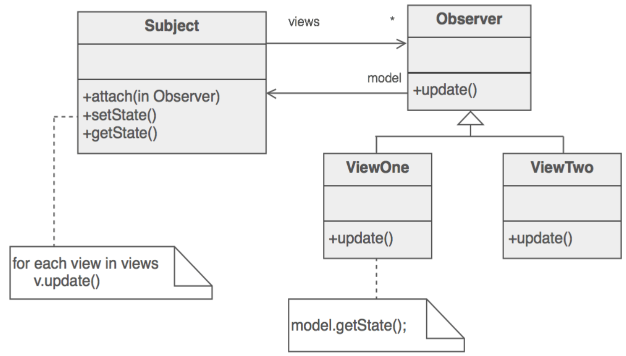



## Strategy: Sequence Diagram Draft




- **Not** an accurate Sequence Diagram.

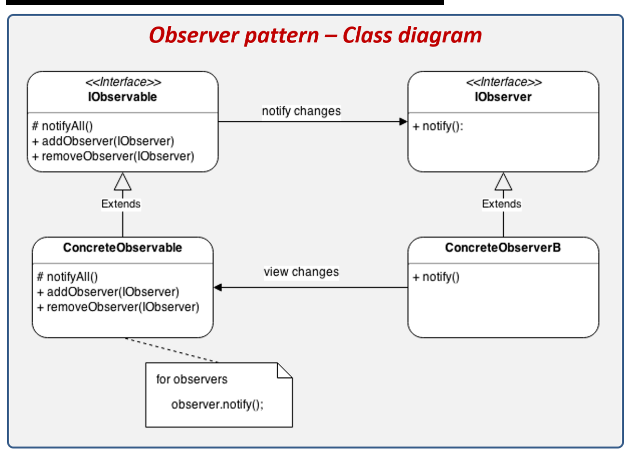
## Observer Pattern



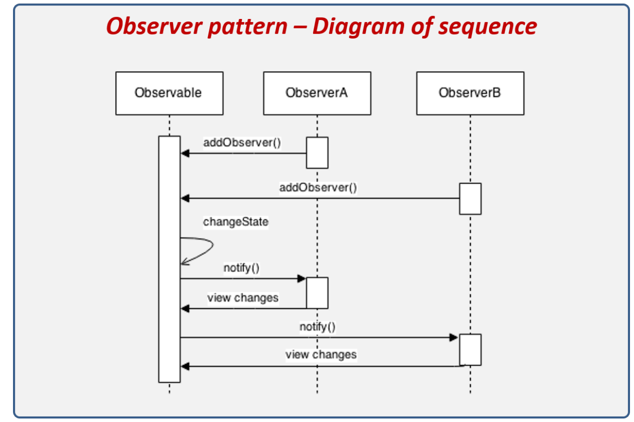

- Subject: interface of all observable subject classes, in it, methods that (1) keep track of observers listening to itself (2) notify the observers when change happens, are defined.
- Concrete Subject: the observable class; it implements all methods defined in Subject interface.
- Observer: interface observing the changes on Subject.
- Concrete Observer: Concrete class watching the changes on Subject, inherits from Observer, implements its methods.

It defines a one-to-many dependency between objects so that when one object (a concrete observable subject) changes state, all of its dependents (corresponding concrete observers) are notified and updated automatically.

## Observer: Class Diagram Draft

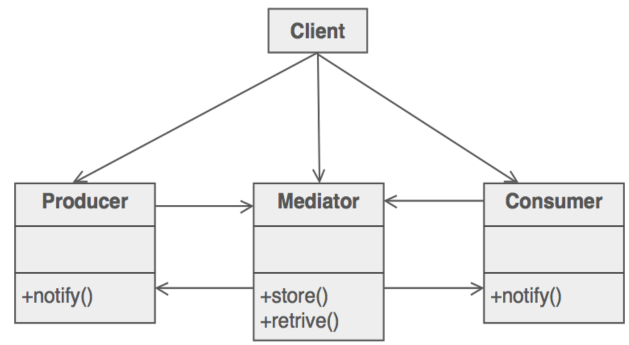



## Observer: Sequence Diagram Draft




- **Not** an accurate Sequence Diagram.

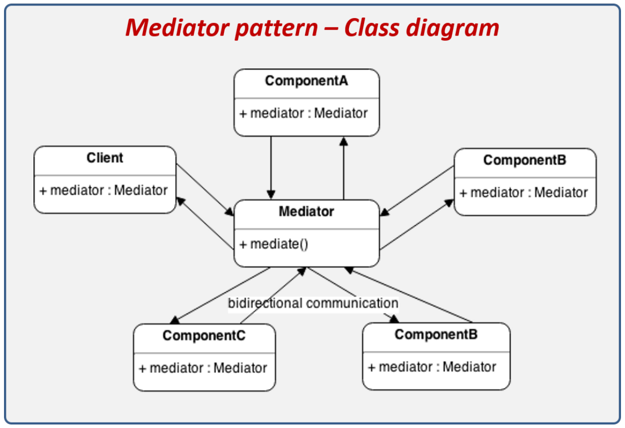
## Mediator Pattern



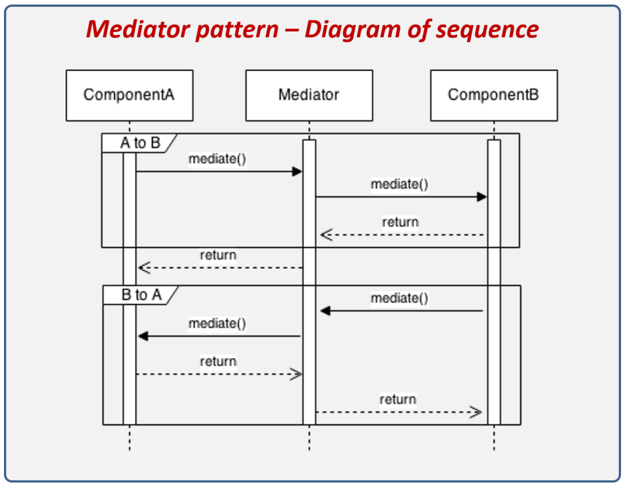

- Mediator: defines the interface for communication between colleague objects.
- Concrete Mediator: implements the mediator interface and coordinates communication between colleague objects.
- Colleague (Peer): defines the interface for communication with other colleagues
- Concrete Colleague: implements the colleague interface and communicates with other colleagues through its mediator only; e.g. Producer, Consumer in the figure.

Centralize many-to-many complex communications and control between related objects (colleagues).

## Mediator: Class Diagram Draft

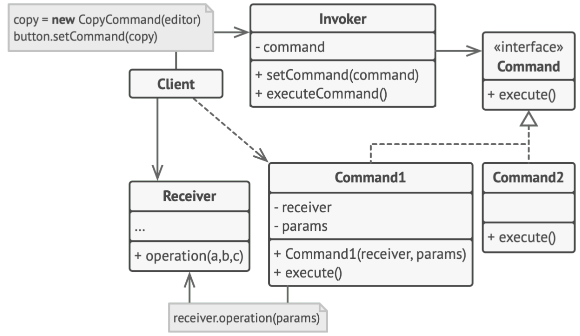



## Mediator: Sequence Diagram Draft




- **Not** an accurate Sequence Diagram.

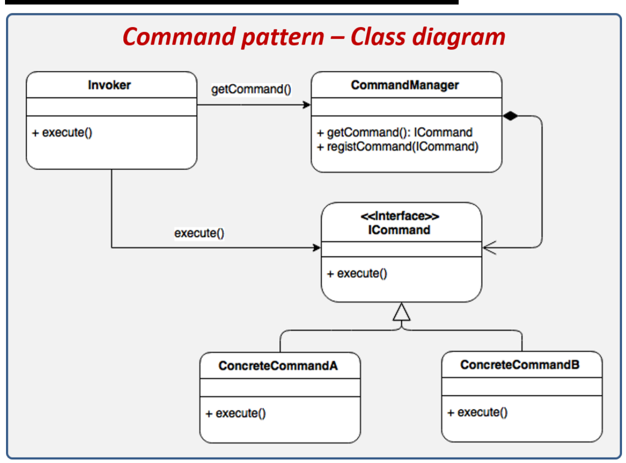
## Command Pattern



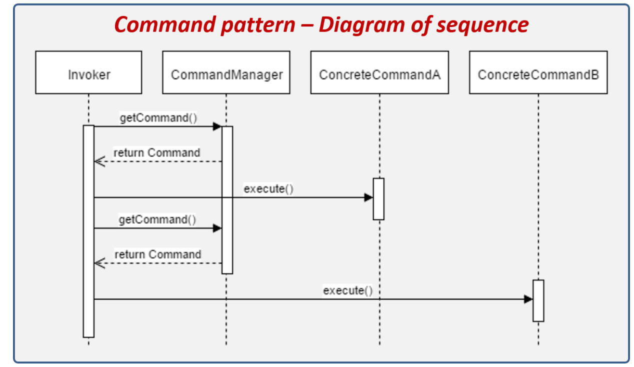

- Command: interface describing the structure of the commands, defining the generic execution method for all of them (e.g. execute, undo).
- Concrete Command: inheriting from Command, each of these classes represents a command that can be executed independently.
- Receiver: informed by the Concrete Command and take actions.
- Invoker: the action triggering one of the commands, hold a command and at some point execute it.
- (optional) Command Manager: manage all the commands available at runtime, from here we create / request commands.

The Command pattern allows requests to be encapsulated as objects, thereby allowing clients to be parameterized with different requests.

## Command: Class Diagram Draft

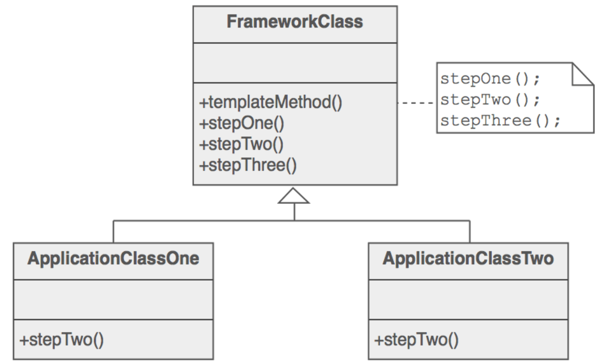



## Command: Sequence Diagram Draft




- **Not** an accurate Sequence Diagram.

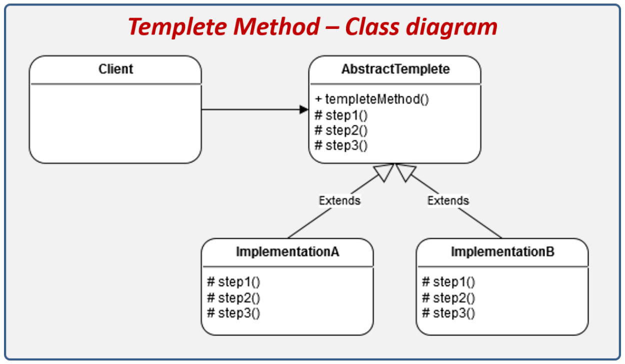
## Template Method Pattern



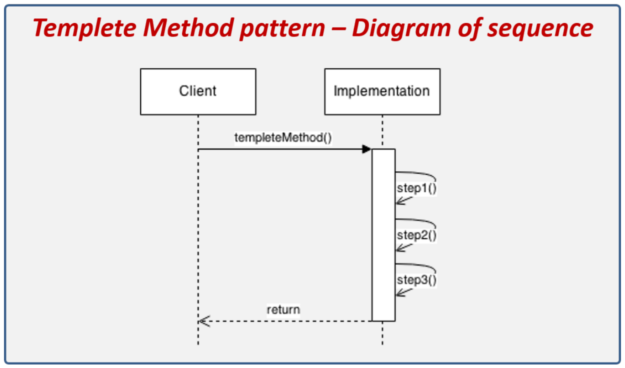

- Abstract Template: an abstract class including a series of operations which define the necessary steps for carrying out the execution of the algorithm; e.g. Framework Class in the figure.
- Implementation: the class inherits from Abstract Template and implements its methods to complete the algorithm; e.g. Application Class One / Two in the figure.

The Template Method Pattern defines the skeleton of an algorithm in a method, deferring some steps to subclasses; subclasses may redefine certain steps of an algorithm without changing its overall structure.

## Template Method: Class Diagram Draft

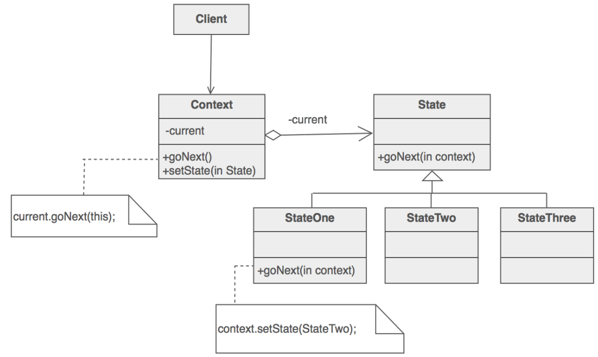



## Template Method: Sequence Diagram Draft



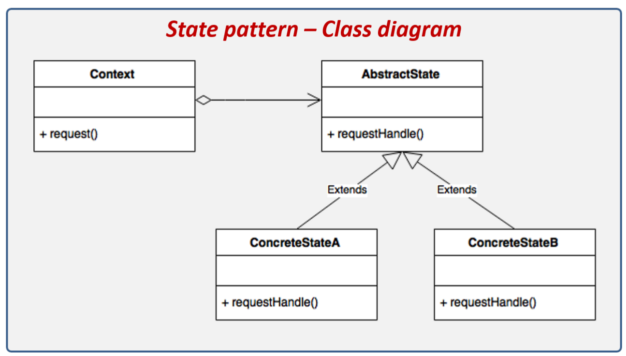

- **Not** an accurate Sequence Diagram.

## State Pattern

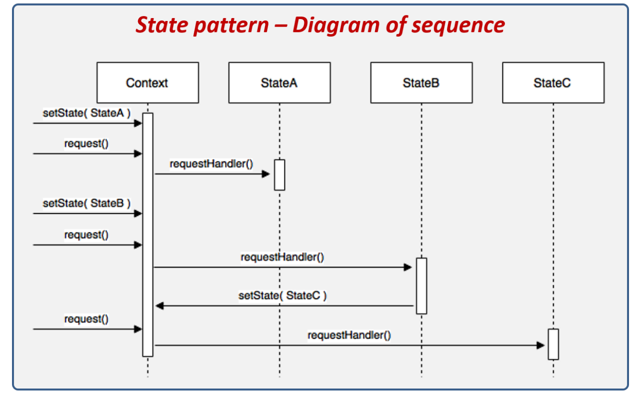



- Context: the component subject to changing states, it has its current state as one of its properties; e.g. in a vending machine example, this would represent the machine.
- State: abstract base class used for generating different states, usually works better as an abstract class, instead of as an interface, because it allows us to set default behaviors.
- Concrete State: inherit from State, each one of these represent a possible state the application could go through during its execution.

## State: Class Diagram Draft




## State: Sequence Diagram Draft




- **Not** an accurate Sequence Diagram.