04834580 Software Engineering (Honor Track) 2024-25

Behavioral Design Patterns

Sergey Mechtaev
mechtaev@pku.edu.cn
School of Computer Science, Peking University

Iterator

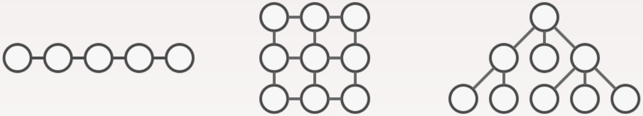
Definition ([1])

Provide a way to access the elements of an aggregate object sequentially without exposing its underlying representation.

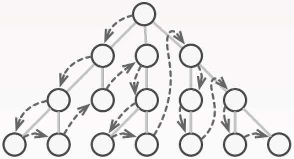
Iterator: Motivation

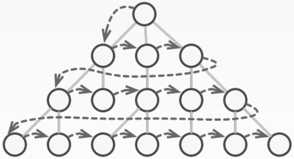
北京大学

There are various types of collections:

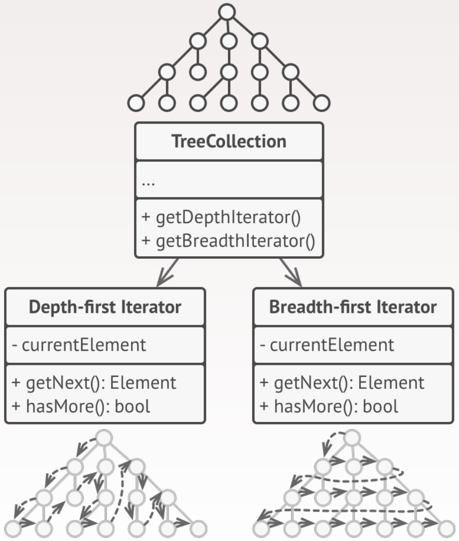


The same collection can be traversed in several different ways.

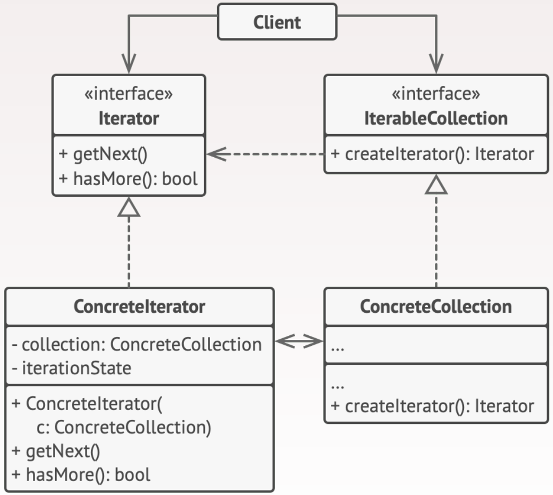




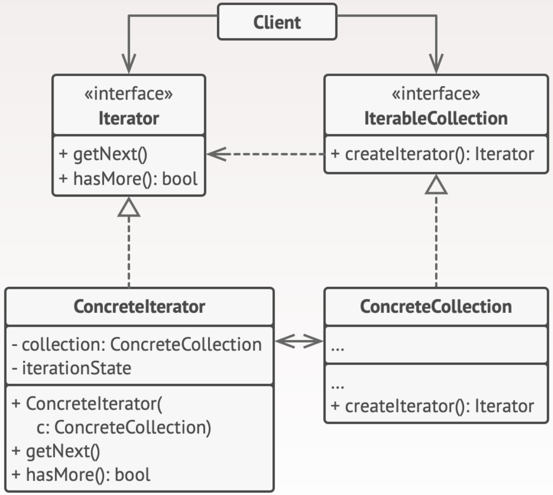
Iterator: Motivation



Iterator: General Structure



Iterator: General Structure



Iterators in Python

Exceptions are used instead of `hasNext()`:

```
class Iterator:
  def __next__(self):
    if self.has_more_elements():
      return self.next_element()
    raise StopIteration

it = Iterator()
elem = next(it) # or elem = next(it, default)
```

Iterators in Python

北京大学

An iterator is obtained from an iterable using `iter()`:

```python
class Iterable:
  def __iter__(self):
    return Iterator()

x = Iterable()
it = iter(x)
```

Notable iterables:

- lists, dicts, sets;
- strings are iterables over characters;
- `range(end)`, `range(begin, end)`;
- `open(‘‘a.txt’’)` is iterable over lines if the file.

Iterators in Python

Iterators are iterables:

```python
class Iterator:
  def __next__(self):
    ...

  def __iter__(self):
    return self
```

Iterators in Python

For loops are implemented using iterators:

```
for x in xs:
  body
```

```
it = xs.__iter__()
while True:
  try:
    x = it.__next__()
  except StopIteration:
    break

  body
```

Iterators in Python

Generator functions behave like iterators:

```
def fibonacci():
    """Generator for the Fibonacci sequence."""
    a, b = 0, 1
    while True:
        yield a
        a, b = b, a + b

# Using the generator
fib_gen = fibonacci()

# Print the first 10 Fibonacci numbers
for _ in range(10):
    print(next(fib_gen))
```

Iterators in Python

Representing infinite sequences:

```python
from itertools import islice, count

# This generates an infinite sequence of integers starting from 0.
infinite_sequence = count(start=0)

# Use map() to apply a transformation.
mapped_sequence = map(lambda x: x * x, infinite_sequence)

# Use islice() to slice the sequence and take only the nth element.
n = 5
nth_element = next(islice(mapped_sequence, n, n + 1))

print(f"The {n}th element of the mapped sequence is: {nth_element}")
```

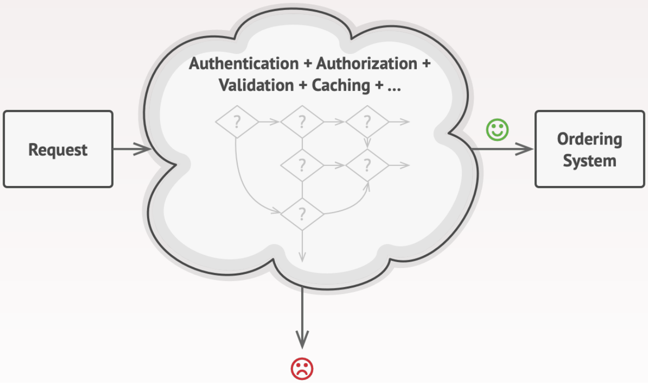
Chain of Responsibility

Definition ([1])

Avoid coupling the sender of a request to its receiver by giving more than one object a chance to handle the request. Chain the receiving objects and pass the request along the chain until an object handles it.

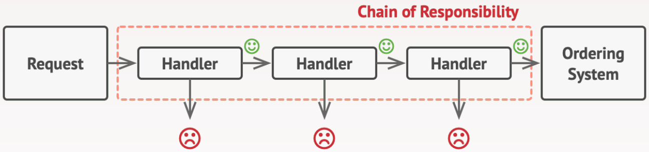
Chain of Responsibility: Motivation

Complex logic of checks might make the system hard to maintain and extend:



Chain of Responsibility: Motivation

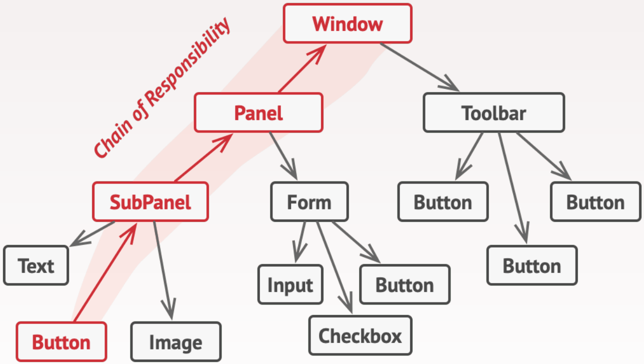
CoR transforms particular behaviors into stand-alone objects called handlers, links these handlers into a chain:



Chain of Responsibility: Motivation

北京大學

Dealing with events in GUI with chain of responsibility in a tree:



Chain of Responsibility

北京大学

The default chaining behavior can be implemented inside a base handler:

```python
class AbstractHandler:
    _next_handler: Handler = None

    def set_next(self, handler: Handler) -> Handler:
        self._next_handler = handler
        return handler

    @abstractmethod
    def handle(self, request: Any) -> str:
        if self._next_handler:
            return self._next_handler.handle(request)
        return None
```

Chain of Responsibility

Concrete handlers:

```python
class MonkeyHandler(AbstractHandler):
    def handle(self, request: Any) -> str:
        if request == "Banana":
            return f"Monkey: I'll eat the {request}"
        else:
            return super().handle(request)


class SquirrelHandler(AbstractHandler):
    def handle(self, request: Any) -> str:
        if request == "Nut":
            return f"Squirrel: I'll eat the {request}"
        else:
            return super().handle(request)
```

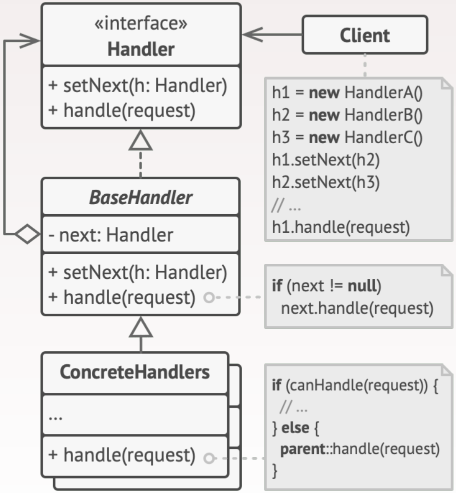
Chain of Responsibility

北京大學

Chaining handlers in client code:

```
if __name__ == "__main__":
    monkey = MonkeyHandler()
    squirrel = SquirrelHandler()
    dog = DogHandler()

    monkey.set_next(squirrel).set_next(dog)

    for food in ["Nut", "Banana", "Cup of coffee"]:
        print(f"\nClient: Who wants a {food}?")
        result = handler.handle(food)
        if result:
            print(f"  {result}", end="")
        else:
            print(f"  {food} was left untouched.", end="")
```

Chain of Responsibility: General Structure



```
h1 = new HandlerA()
h2 = new HandlerB()
h3 = new HandlerC()
h1.setNext(h2)
h2.setNext(h3)
// ...
h1.handle(request)
```

```
if (next != null)
  next.handle(request)
```

```
if (canHandle(request)) {
  // ...
} else {
  parent::handle(request)
}
```

Mediator

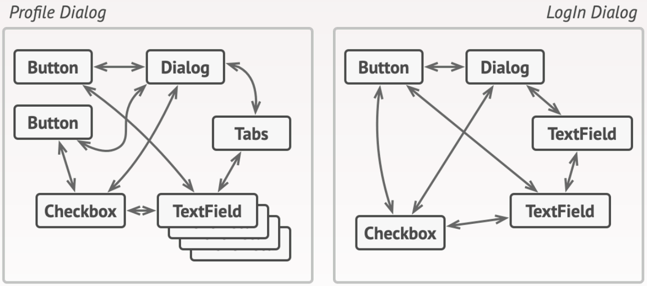
北京大学

Definition ([1])

Define an object that encapsulates how a set of objects interact. Mediator promotes loose coupling by keeping objects from referring to each other explicitly, and it lets you vary their interaction independently.

Mediator: Motivation

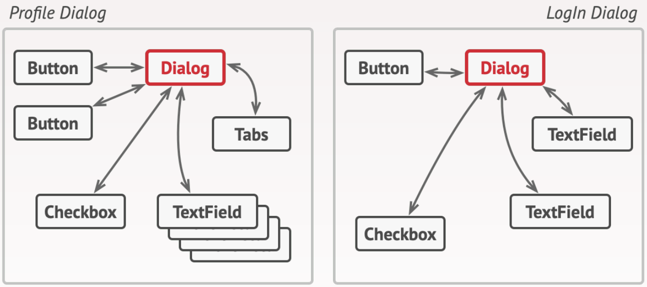
By having the logic of interactions implemented directly inside the code of the form elements you make these elements' classes much harder to reuse in other forms of the app:



Mediator: Motivation

北京大学

Cease all direct communication between the components; these components must collaborate indirectly:



Mediator

The mediator interface declares a method used by components to notify the mediator about various events:

```
class ConcreteMediator(Mediator):
    def __init__(self, component1: Component1, component2: Component2) -> None:
        self._component1 = component1
        self._component1.mediator = self
        self._component2 = component2
        self._component2.mediator = self

    def notify(self, sender: object, event: str) -> None:
        if event == "A":
            print("Mediator reacts on A and triggers following operations:")
            self._component2.do_c()
        elif event == "D":
            print("Mediator reacts on D and triggers following operations:")
            self._component1.do_b()
            self._component2.do_c()
```

Mediator

The Base Component provides the basic functionality of storing a mediator's instance inside component objects:

```python
class BaseComponent:
    def __init__(self, mediator: Mediator = None) -> None:
        self._mediator = mediator

    @property
    def mediator(self) -> Mediator:
        return self._mediator

    @mediator.setter
    def mediator(self, mediator: Mediator) -> None:
        self._mediator = mediator
```

Mediator

Concrete Components implement various functionality, independent on other components or concrete mediators:

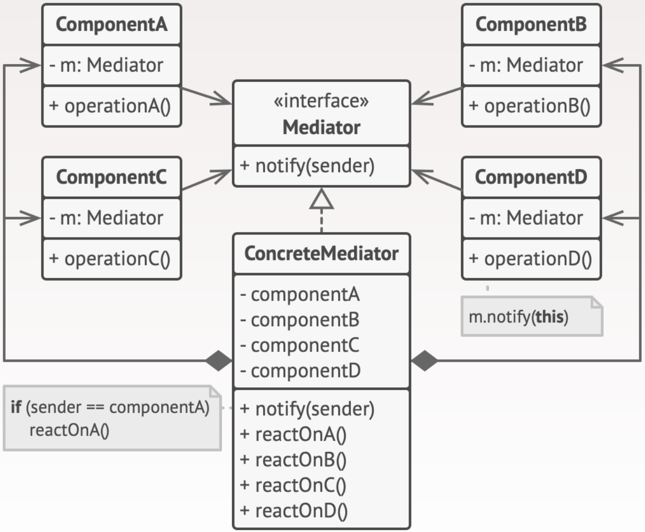
```python
class Component1(BaseComponent):
    def do_a(self) -> None:
        print("Component 1 does A.")
        self.mediator.notify(self, "A")

    def do_b(self) -> None:
        print("Component 1 does B.")
        self.mediator.notify(self, "B")


class Component2(BaseComponent):
    def do_c(self) -> None:
        print("Component 2 does C.")
        self.mediator.notify(self, "C")

    def do_d(self) -> None:
        print("Component 2 does D.")
        self.mediator.notify(self, "D")
```

Mediator

Using mediator in client code:

```
if __name__ == "__main__":
    # The client code.
    c1 = Component1()
    c2 = Component2()
    mediator = ConcreteMediator(c1, c2)

    print("Client triggers operation A.")
    c1.do_a()

    print("\n", end="")

    print("Client triggers operation D.")
    c2.do_d()
```

Mediator: General Structure



Observer

Definition ([1])

Define a one-to-many dependency between objects so that when one object changes state, all its dependents are notified and updated automatically.

Observer

```java
public class EventManager {
    Map<String, List<EventListener>> listeners = new HashMap<>();

    public EventManager(String... operations) {
        for (String operation : operations) {
            this.listeners.put(operation, new ArrayList<>());
        }
    }

    public void subscribe(String eventType, EventListener listener) {
        List<EventListener> users = listeners.get(eventType);
        users.add(listener);
    }

    public void unsubscribe(String eventType, EventListener listener) {
        List<EventListener> users = listeners.get(eventType);
        users.remove(listener);
    }

    public void notify(String eventType, File file) {
        List<EventListener> users = listeners.get(eventType);
        for (EventListener listener : users) {
            listener.update(eventType, file);
        }
    }
}
```

Observer

```java
public class Editor {
    public EventManager events;
    private File file;

    public Editor() {
        this.events = new EventManager("open", "save");
    }

    public void openFile(String filePath) {
        this.file = new File(filePath);
        events.notify("open", file);
    }

    public void saveFile() throws Exception {
        if (this.file != null) {
            events.notify("save", file);
        } else {
            throw new Exception("Please open a file first.");
        }
    }
}
```

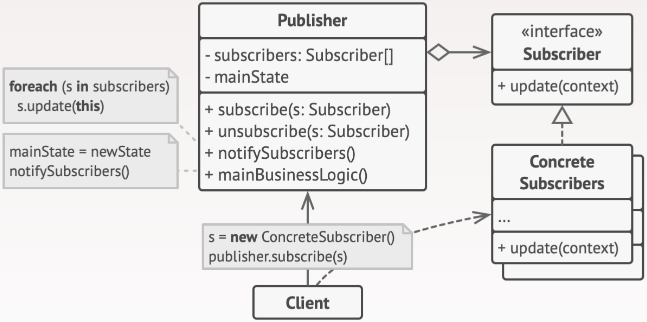
Observer

```
public interface EventListener {
    void update(String eventType, File file);
}

public class EmailNotificationListener implements EventListener {
    private String email;

    public EmailNotificationListener(String email) {
        this.email = email;
    }

    @Override
    public void update(String eventType, File file) {
      System.out.println("Email to " + email + ": Someone has performed " +
          eventType + " operation with the following file: " + file.getName());
    }
}
```

Observer

```java
public class Demo {
    public static void main(String[] args) {
        Editor editor = new Editor();
        editor.events.subscribe("open", new LogOpenListener("/path/to/log/file.txt"));
        editor.events.subscribe("save",
            new EmailNotificationListener("admin@example.com"));

        try {
            editor.openFile("test.txt");
            editor.saveFile();
        } catch (Exception e) {
            e.printStackTrace();
        }
    }
}
```

Observer: General Structure



```
foreach (s in subscribers)
  s.update(this)
```

```
mainState = newState
notifySubscribers()
```

```
s = new ConcreteSubscriber()
publisher.subscribe(s)
```

Strategy

Definition ([1])

Define a family of algorithms, encapsulate each one, and make them interchangeable. Strategy lets the algorithm vary independently from clients that use it.

Strategy

The Context defines the interface of interest to clients:

```
class Context():
    def __init__(self, strategy: Strategy) -> None:
        self._strategy = strategy

    @property
    def strategy(self) -> Strategy:
        return self._strategy

    @strategy.setter
    def strategy(self, strategy: Strategy) -> None:
        self._strategy = strategy

    def do_some_business_logic(self) -> None:
        print("Context: Sorting data using the strategy (not sure how it'll do it)")
        result = self._strategy.do_algorithm(["a", "b", "c", "d", "e"])
        # ...
```

Strategy

Concrete strategies:

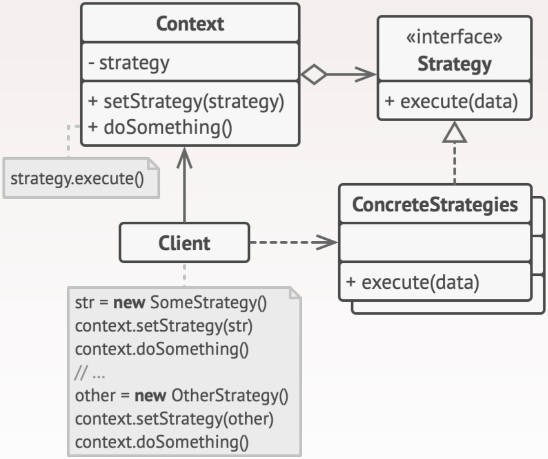
```
class ConcreteStrategyA(Strategy):
    def do_algorithm(self, data: List) -> List:
        return sorted(data)


class ConcreteStrategyB(Strategy):
    def do_algorithm(self, data: List) -> List:
        return reversed(sorted(data))
```

Strategy

Using strategies in client code:

```
if __name__ == "__main__":
    context = Context(ConcreteStrategyA())
    print("Client: Strategy is set to normal sorting.")
    context.do_some_business_logic()
    print()

    print("Client: Strategy is set to reverse sorting.")
    context.strategy = ConcreteStrategyB()
    context.do_some_business_logic()
```

Strategy: General Structure



```
str = new SomeStrategy()
context.setStrategy(str)
context.doSomething()
// ...
other = new OtherStrategy()
context.setStrategy(other)
context.doSomething()
```

References I

[1] Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides.
Design patterns: elements of reusable object-oriented software.
Pearson Deutschland GmbH, 1995.