Iterating collections

The INFDEV team

Dev 4 - Lecture topics

Breaking down design patterns

Iterating collections

The iterator design pattern

Iterating collections

The INFDEV team

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Dev 4 - Lecture topics

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Lecture topics

- Breaking down design patterns, an introduction
- Iterating collections
- Concrete examples of the iterator design pattern
- Conclusions

Breaking down design patterns

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Introduction

- After having seen the 1st design pattern, we can add some depth to the discussion
- Design patterns have been grouped in several specific categories:
- Behavioral
- Structural
- Creational
- In this course we will always try, when introducing a design pattern, to picture it with respect to such categories

Breaking down design patterns

Behavioral patterns

- design patterns for identifying the fundamental communication behavior between entities
- Among such pattern we find:

- **Visitor pattern**
- State pattern
- Strategy pattern
- **Null Object pattern**
- Iterator pattern
- etc..

Breaking down design patterns

Structural patterns

- Are design patterns that ease the design of an application by identifying a simple way to implement relationships between entities
- Among such pattern we find:

- Adapter pattern
- Decorator pattern
- Proxy pattern
- etc..

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Creational patterns

- Are design patterns that deal with entities creation mechanisms, trying to create entities in a manner suitable to the situation
- They make it possible to have “virtual” constructors
- Among such pattern we find:

- Factory method pattern
- Lazy initialization pattern
- Singleton pattern
- etc..

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Software development principles

- Even more abstractly, design patterns are all rooted in the same principles
- These principles make it possible to derive old and new patterns

Breaking down design patterns

Software development principles

- Such principles are:

DRY : Is an acronym for the design principle “Don’t Repeat Yourself”

KISS : Is an acronym for the design principle “Keep it simple, Stupid!”

SOLID : Is an acronym for Single responsibility, Open-closed, Liskov substitution, Interface segregation, and Dependency inversion

Breaking down design patterns

Software development principles

- In this course we will always try, when introducing a design pattern, to present it along with its principles

Iterating collections

Iterating collections

Introduction

- Today we are going to study collections
- In particular, we are going to study how to access the elements of a collection without exposing its underlying representation (methods and fields)
- How? By means of a design pattern: the iterator (a behavioral design pattern)
- We will see how the iterator provides a clean, almost trivial, general way representation for iterating collections

Iterating collections

About collections

- They come in different shapes and implementations:
- Option (an option essentially is a “one-element‘ collections”)
- Stream of data
- Records of a database
- List of cars
- Array of numbers
- Array of Array of pixels (a matrix)
- etc..

Iterating collections

What do we do with collections?

- However, all collections, from options to arrays, exhibit similarities
- The, *general* idea is going through all its elements one by one until there are no more to see

Iterating collections

What do we do with collections?

- Unfortunately, every collection has its own different implementation
- This is an issue
- Why?

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Iterating collections

What do we do with collections?

- Unfortunately, every collection has its own different implementation
- This is an issue
- Why?
- Because we would have to write specific code for each collection

Iterating collections

Similar collections, but with different implementation

- Take for example a linked list and an array:
- The former is a dynamic data structure made of linked nodes. A linked list potentially might contains infinite nodes
- The latter is a static compact data structure. In an array the maximum number of elements is fixed

Iterating collections

Iterating lists

- Iterating a list requires a variable that references the current node in the list
- To move to the next node we need to manually update such variable, by assigning to it a reference to the next node

```
...
LinkedList<int> list_of_numbers = new LinkedList<int>();
while (list_of_numbers.Tail != null) {
  ...
  list_of_numbers = list_of_numbers.Tail;
 }
...
```

Iterating collections

Iterating array

- Iterating an array requires a variable (an index) containing a number representing the position of the current visited element
- To move to the next element we need to manually update the variable, increasing it by one.

```
...
int[] array_of_numbers = new int[5];
int index;
for(index = 0;(index <= array_of_numbers.Length);index = (index + 1)){
  ...
 }
...
```

Iterating collections

The need for different collections

- A collection has its own use: for example arrays are very performant in retrieving data at specific positions, linked lists allow fast insertions, etc..
- But then how can we hide the implementation details so that iterating collections becomes trivial if the specifics are not relevant?

Iterating collections

Issues

- Repeating code is problematic (DRY: do not repeat iteration logic)
- Knowing too much about a data structure increases coupling make code more complex (KISS: keep iteration simple)

Iterating collections

Our goal

- We try to achieve a mechanism that abstracts our concrete collections from their iteration algorithms
- Iteration is a behavior common to all collections: only its implementation changes

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Iterating collections

The iterator design pattern

How do we achieve it?

- We wish to delegate the implementation of such algorithms to each concrete collection
- We control such algorithms by means of a common/shared interface

Iterating collections

What follows?

- When developers need to iterate a collection they simply use the interface provided by the chosen collection
- Such interface hides the internals of a collection and provides a clean interaction surface for iterating it

Iterating collections

The iterator design pattern

- Is a design pattern that captures the iteration mechanism
- We will now study it in detail and provide a series of examples

The iterator design pattern

The iterator design pattern

The iterator design pattern

- Is an interface `Iterator<T>` containing the following method signature

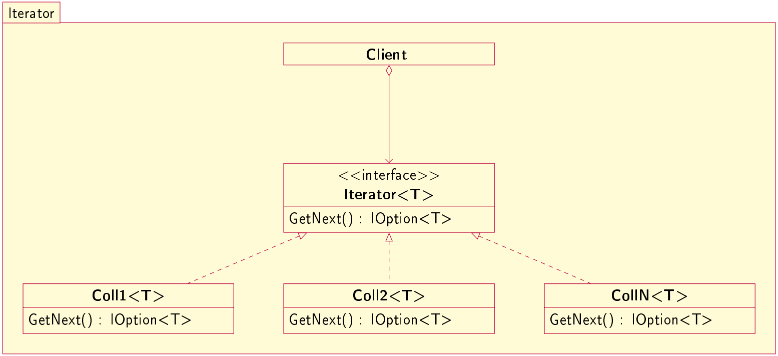
```
interface Iterator<T> {
  IOption<T> GetNext();
}
```

The iterator design pattern

Implementing the Iterator<T>

- At this point every collection that wants to provide a disciplined and controlled iteration mechanism has to implement such interface

The iterator design pattern



The iterator design pattern

Implementing the Iterator<T>

- We now show a series of collections implementing such our interface

The iterator design pattern

Natural numbers

- The natural numbers are all integers greater or equals to 0
- We now wish to define a collection containing all natural numbers
- To do so we define a data structure that implements our iterator
- And starting from -1 (the successor of it is 0, the first natural number), which is stored in a field called `current`, whenever we call the `GetNext` method we increase such `current` and returns its value

```
class NaturalList : Iterator<int> {
  private int current = -1;
  IOption<int> GetNext() {
    current = 1return new Some<int>(current);
  }
}
```

The iterator design pattern

Array<T>

- Dealing with array requires to deal with its indexes
- We hide such complexity, which often is error-prone, by means of our iterator

The iterator design pattern

Array<T>

- Our “new” array takes as input an object of type array
- Aa field index keeps tracking of the current index
- Whenever the GetNext method is called we check whether we reached the end of the array: if so we return None, otherwise we increase the index and return the value of the array at position index wrapped inside a Some object

```
class Array<T> : Iterator<T> {
  private T[] array;
  private int index = -1;
  public Array(T[] array) {
    this.array = array;
  }
  IOption<int> GetNext() {
    if ((index + 1) < array.Length) {
      return new None<T>();
    }
    else{
      index = (index + 1);
      return new Some<int>(array[index]);
    }
  }
```

The iterator design pattern

The iterator in literature

- In literature it is often the case to see our Iterator as an interface containing the following signatures

```
interface UnsafeIterator<T> {
  bool MoveNext();
  T GetCurrent();
}
```

- The main big difference now is that whenever we need to coordinate `GetCurrent` and `MoveNext` in order to move through the collection
- This adds a layer of complexity to the iterator that (to some extent) is not necessary. After all we only want to go iterate all items of a collection
- In what follow we show how to adapt entities implementing this interface with our original `Iterator<T>` interface

The iterator design pattern

Improving the UnsafeIterator<T> safeness

- Adapting our `UnsafeIterator` will require us to define an adapter `AdapterIterator` that implements our `Iterator`
- The `AdapterIterator` takes as input an `UnsafeIterator` and whenever the `GetNext` method is called it calls `GetCurrent` and `MoveNext` accordingly

```
class AdapterIterator<T> : Iterator<T> {
  private UnsafeIterator<T> iterator;
  public AdapterIterator(UnsafeIterator<T> iterator) {
    this.iterator = iterator;
  }
  IOption<int> GetNext() {
    if iterator.MoveNext();
 {
      return new Some<int>(iterator. GetCurrent());
    }
    else{
      return new None<T>();
    }
  }
}
```

The iterator design pattern

AdapterIterator examples of usage

- In what follows we show how to use our adapter
- Note in this case `NaturalList` is a class that implements the `UnsafeIterator` interface

```
Iterator<int> iterator = new AdapterIterator<int>(new NaturalList());
```

The iterator design pattern

Conclusions

- Iterating collections is a time consuming, error-prone, activity, since collections come with different implementations each with its own complexity
- Iterators are a mechanism that hides the complexity of a collection and provides a clean interaction surface to iterate them
- This mechanism not only reduces the amount of code to write (achieving then the DRY principle), but also reduces the amount of coupling

This is it!

The best of luck, and thanks for the attention!