Introduction

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Introduction

Introduction

Lecture topics

- Intro to DEV4
- Design patterns introduction
- The visitor design pattern
- Course agenda
- Conclusions

Introduction

What you have done so far?

- Encapsulation, polymorphism, subtyping, generics, etc.;
- Powerful ways to express interactions among objects.

Introduction

What we have not told you?

- Maybe you have already noticed it;
- Interactions affect coupling.

What is coupling?

- If changing one module in a program requires changing another module, then we have coupling.

Introduction

High-coupling

- As the interaction surface between two classes **A** and **B** increases, the coupling between them increases as well;
- This translates into: whenever **A** changes the chance to erroneously change **B** is "high";
- Thus, the amount of bugs.

```
1  class Driver {
2    private Car car;
3    void Drive() {
4      public this.car.Move();
5    }
6  }
7  class Car {
8    public void Move() {
9  ...
10   }
11 }
```

Introduction

Low-coupling

- The interaction surface between two classes **A** and **B** is limited to a series of methods provided by an interface;
- This translates into: whenever **A** changes the chance to erroneously change **B** is "low", since **A** know little about **B**.

```
1  class Driver {
2    private Vehicle vehicle;
3    void Drive() {
4      public this.vehicle.Move();
5    }
6  }
7  interface Vehicle {
8    void Move();
9  }
10 class Car : Vehicle {
11   public void Move() {
12 ...
13   }
14 }
```

Low vs High coupling

- As the amount of entities increase, the of amount interactions increases (especially if the interfaces are not clear or not used at all);
- How much?
- It is a very big number (we are talking about an exponential function) depending on the amount of interacting objects;
- More precisely, given C classes, it is:

$$O\left(\sum_{1<k\leq C} \frac{C!}{2(C-k)!}\right)$$

Finding the right amount of coupling

- One could argue that: to avoid coupling we can put everything in one big class;
- Unfortunately this is completely true, since we can have coupling also within a single class.

Achieving low-coupling

- What seems desirable when dealing with software development is to keep coupling (our interactions) among entities as low as possible;
- Why?
- To mainly keep code maintainable.

Introduction

Maintainability in code

- Is an important aspect in development;
- It affects costs, code customization, bug fixing, etc.

Achieving low-coupling

- How how can we reduce the interaction surface among objects??
- We can use polymorphism, as seen in the last example, as a tool for specifying interaction surfaces.

Introduction

Low-coupling a general view

- Given two classes `A` and `B`;
- `A` interacts with an `I_B` interface, whenever `A` needs to interact with an instance of type `B`;
- `B` interacts with an `I_A` interface, whenever `B` needs to interact with an instance of type `A`.

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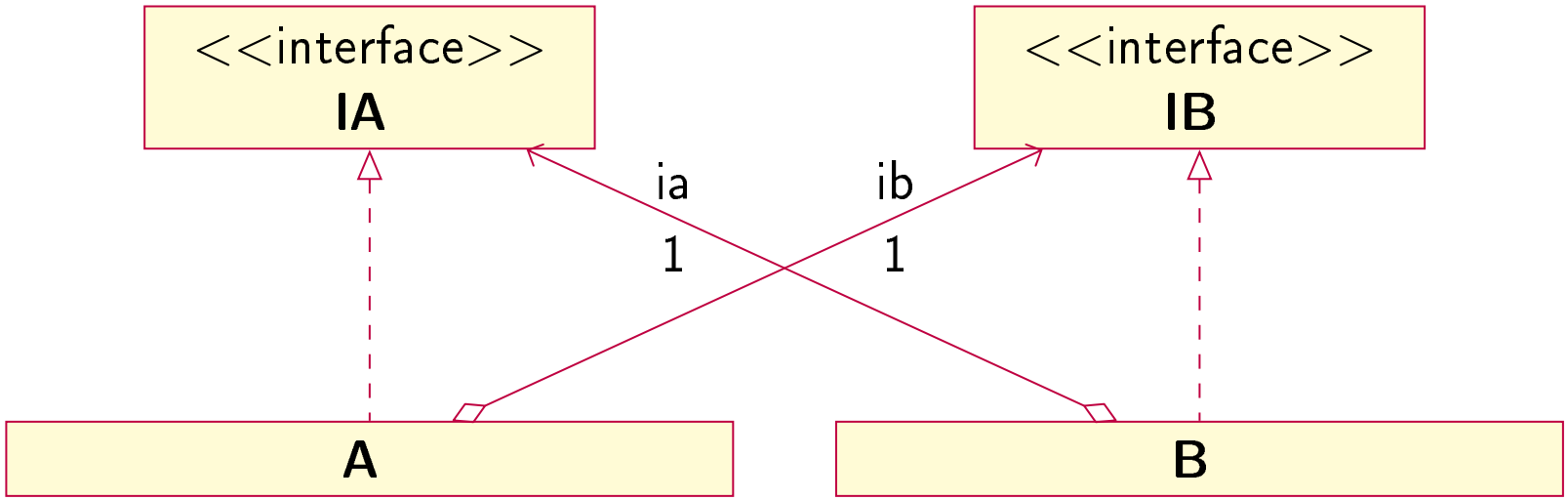


Introduction

Polymorphism for taming coupling in programs

- We can now control interactions by means of an interface that hides the specifics of some classes;
- Now every entity interacts with another only through small "windows" (defined as interfaces) each exposing specific and controlled behavior.

Introduction


```
1  class Driver {
2    private Vehicle vehicle;
3    void Drive() {
4      public this.vehicle.Move();
5    }
6  }
7  interface Vehicle {
8    void Move();
9  }
10 class Car : Vehicle {
11   private Engine engine;
12   public void Move() {
13 ...
14   }
15 }
```

- The driver can yes interact with a vehicle, but only with its public `Move` method;
- The `engine`, which should not be accessible outside the car, is not mentioned in the interface, so the driver cannot interact with it.

Introduction

Recurrent patterns in objects interactions

- Disciplined interactions such as the one above tend to exhibit some recurring high level strutures;
- Such recurrent structures are known under the umbrella term of **design patterns**.

Introduction

Design Patterns

- Design patterns in short are: ways to capture recurrent patterns for expressing controlled interactions between objects;
- We will now see a specific example of such a pattern.

Our first design pattern

Our first design pattern

Choosing in the presence of polymorphism

- As you already know polymorphism is a powerful mechanism that allows decomposition and code reuse;
- However, polymorphism becomes dangerous when given a general[a] instance we have to choose what its specific shape is.

[a] Cat is Animal. Cat is specific. Animal is general.

Our first design pattern

Why is choosing concrete types so dangerous?

- Mainly because a general type has no information about what classes are implementing it.

```
1 interface Vehicle {
2   void Move();
3 }
4 class Car : Vehicle {
5 ...
6 }
7 class Bike : Vehicle {
8 ...
9 }
```

- Given an instance `v` of type `Vehicle`, what can we say about the concrete type of `v`?
- Is it a `Car` or a `Bike`?
- What if we want to turn on the lights of the car of `v`?

Our first design pattern

Safe choice in the presence of polymorphism

- We need a mechanism that allows us to manipulate polymorphic instances as if they were concrete;
- Concrete instances are the only ones who know their identity, so we allow them to choose from a series of given "options".

Visiting Option's

Visiting Option's

The Option data structure

- Is used when an actual value might not exist for a named value or variable;
- An option has an underlying type and can hold a value of that type, or it might not have a value.

Visiting Option's

Example of usage

- The following code illustrates the use of the option type;
- In this case we are capturing the number 5 within a `Some<int>` object;

```
1 Option<int> a_number = new Some<int>(5);
```

- In this case we captring the "nothing" common to all values of type `int` withing a `None<int>` object;

```
1 Option<int> another_number = new None<int>();
```

Visiting Option's

Some<T> and None<T>

- Both types implement the `Option<T>` data structure;

```
1 class Some<T> : Option<T> { ... }
```

```
1 class None<T> : Option<T> { ... }
```

- `Some<T>` is a container of data, of type `T`, which is ready to get consumed; and
- `None<T>` is a container of data, of type `T`, which is not ready to get consumed yet.

Visiting Option's

Option<T>

- Is an interface that represents both the absence and presence of data of type T

```
1 interface Option<T> { ... }
```

Visiting Option's

Visiting an Option<T>

- As option represents a generic container for any type of objects, we need a mechanism that allows us to manipulate its content regardless its concrete data type;
- We add a method to our interface called `Visit` that accepts as inputs a series of options (in the shape of lambdas) and a generic result;
- Each option will be selected by exactly one of the possible concrete types;
- We decided a propri that the first argument is meant for the class `None<T>` while the second one for the `Some<T>`

```
1 interface Option<T>
2 {
3   U Visit<U>(Func<U> onNone, Func<T, U> onSome)
        ;
4 }
```

Visiting Option's

Visiting a None<T>

- When visiting an object of type None<T> we first select the input reserved for it then we return the result of its call;

```
1  public U Visit<U>(Func<U> onNone, Func<T, U>
       onSome)
2  {
3    return onNone();
4  }
```

Visiting Option's

Visiting a Some<T>

- When instantiating a Some<T> a data of type T is passed and stored inside a field value;
- When visiting an object of type Some<T> we first select the input reserved for it then we return the result of its call with value given as input;
- We pass value to the lambda, since it might be transformed/consumed by it;

```
1  class Some<T> : Option<T>
2  {
3    T value;
4    public Some(T value) { this.value = value; }
5    public U Visit<U>(Func<U> onNone, Func<T, U>
         onSome)
6    {
7      return onSome(value);
8    }
```

Visiting Option's

Testing out our Option<T>

- The next line shows how to use our option to capture numbers and define operations over it;
- More precisely we define a `Some` containing the number 5 with the following operations:
  - The first lambda runs an exception, since we are trying to read a data that is not ready (None represents a `null` object);
  - The second lambda gets as input the `value` stored into `Some` and increments it by 1.

```
1 Option<int> number = new Some<int>(5);
2 int inc_number = number.Visit(() => { throw new
      Exception(\"Expexting␣a␣value..\");␣},␣i␣
    =>␣i␣+␣1);
```

Visiting Option's

Testing out our Option<T>

- The next line shows an example with a None object;
- Visiting such object will indeed cause an exception;

```
1 number = new None<int>();
2 int inc_number = number.Visit(() => { throw new
      Exception("Expexting a value..");}, i
    => i + 1);
```

- As we see we managed to define operations on the fly over polimorphic data types in a controlled way;
- This design will work properly (regadless the data type captured by T) as long as there are always options to choose.

Visiting Option's

More sample

- Can be found on GIT under the folder: Design Patterns Samples C.

The visitor design pattern

The visitor design pattern

The general idea

- What we have seen so far is an example implementing the *visitor* design pattern;
- It allows the recovery of "lost-type" information from a general instance back to specifics;
- The recovery is based on the actualy activation of one of the multiple "options";
- The options can be instances of some concrete visitor interface, or (more elegantly) lambda's;
- We will for now on focus on the lambda implementation.

The visitor design pattern

How do we define it (lambda version)? (Step 1)

- Given: $C_1, ..., C_n$ classes implementing a common interface I;
- Every class C_i has fields $f_i^1, .., f_i^{m_i}$

The visitor design pattern

How do we define it (lambda version)? (Step 2)

- We now add to I a method `Visit` that returns an result of type `U`;
- `Visit`, which is method common to all classes implementing I, picks the right option based on its concrete shape;
- And since we do not know the visit result it returns a result of type generic `sU`

The visitor design pattern

How do we define it (lambda version)? (Step 2)

- The `Visit` method accepts as input arguments as many as the possible concrete classes;
- Every argument is a function that depends on the fields of the concrete instance and produces a result of type `U`.

```
1  interface I<FieldsC_1, FieldsC_2, ..., FieldsC_N>
2    {
3      U Visit<U>(Func<FieldsC_1, U> onC_1,
4                 ...,
5                 Func<FieldsC_N, U> onC_N);
6    }
```

The visitor design pattern

How do we implement it (lambda version)? (Step 3)

- Every class implementing the interface `I` has the task now to implement the `Visit` method, by selecting and calling the appropriate argument.

```
1  class C1<FieldsC1, FieldsC2, ..., FieldsCN>
2        : I<FieldsC1, FieldsC2, ..., FieldsCN>
3    {
4      Input_1 value;
5      U Visit<U>(Func<FieldsC1, U> onC1,
6                 ...,
7                 Func<FieldsCN, U> onCN){
8        onC1(this.value);
9      }
10   }
```

The visitor design pattern

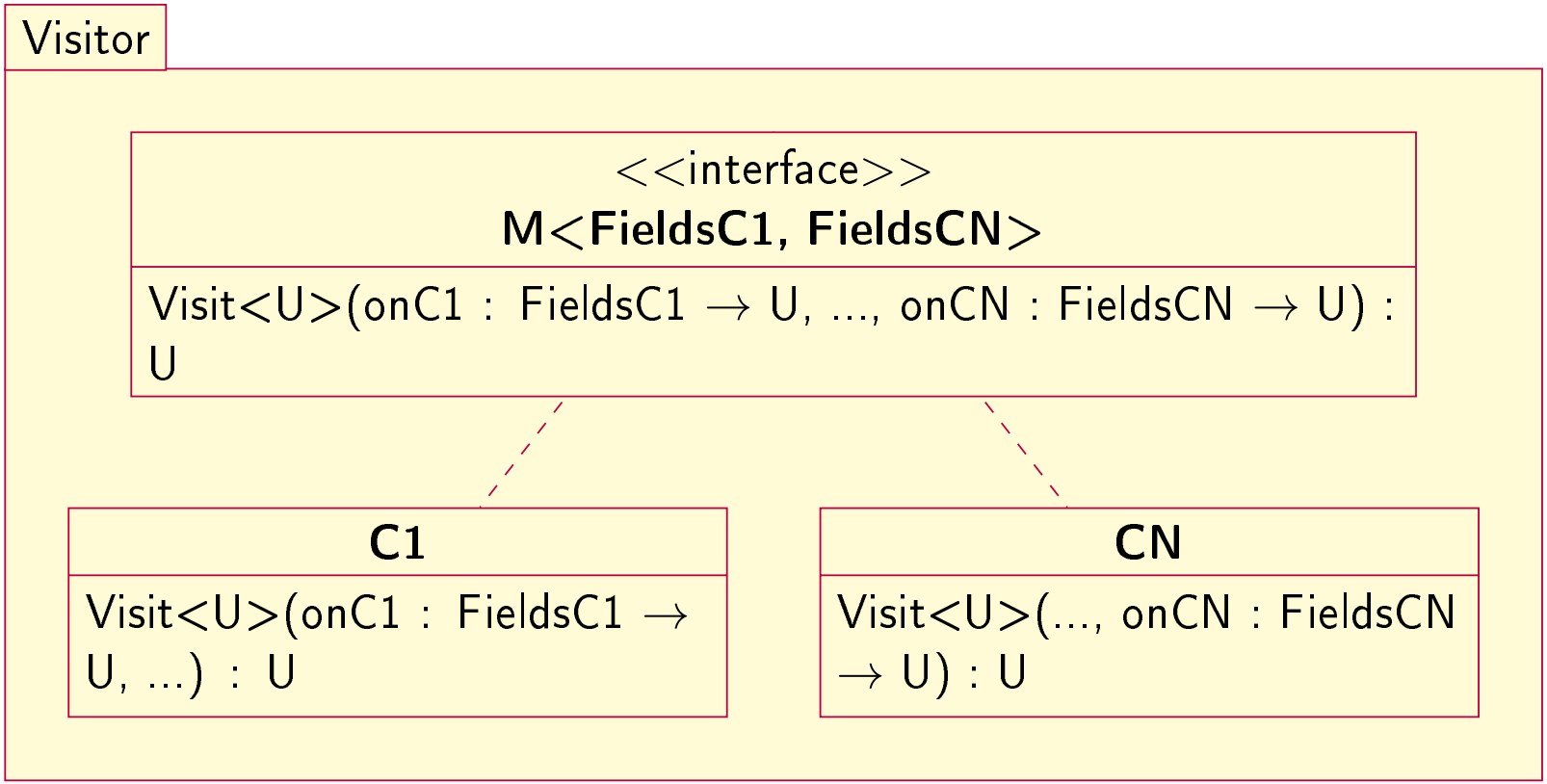
How do we use it (lambda version)? (Step 4)

- Every time we want to consume an instance of type `M` we have to `Visit` it.

```
1  I<FieldsC_1, FieldsC_2, ..., FieldsC_N> i;
2  ...
3  m.Visit(
4   i_1 => b_1,
5   ...,
6   i_N => b_n);
```

- Every argment of the visit becomes a function that is triggered depending on the concrete type of `i`;
- `i_i` are the fields of a concrete class C_i;
- `b_i` is the block of to run when a visit on an instance of a concrete type C_i is needed.

The visitor design pattern



The visitor design pattern

Final considerations

- The visitor patterns provides us with a mechanism to safely manipulate polymorphic instances;
- From the interface point of view: this mechanism is transparent and safe, as there always will be an appropriate function to call;
- From the concrete class point of view: the instance iself is able to select the proper implementation among the input arguments of the visitor method without any complexity or risks.

Course structure

Course structure

Final considerations

- Lectures
  - Intro to design patterns (1 lecture) TODAY
  - Entities construction - Factory (1 lecture)
  - Generalizing behaviors - Adapter (1 lecture)
  - Extending/Composing behaviors - Decorator (1 lecture)
  - Composing patterns - MVC, MVVM (1 lecture)
  - Live coding class (1 lecture)
- Assignment
  - Build a GUI application containing interactive buttons.

Course structure

Conclusions

- Coupling in code is dangerous;
- Unmanaged interactions might introduce bugs;
- Interfaces are powerful means to control interactions.

Course structure

Conclusions

- Software engineering techniques (called design patterns) have been developed to achieve low-coupling by effectively using interfaces;
- This is going to be the topic for this course;
- We will study a series of basic design patterns, used in many applications.

This is it!

The best of luck, and thanks for the attention!