



Programmazione

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Design patterns

“Design patterns are bug reports against your programming language.”

- Peter Norvig





What are design patterns ?

- In software engineering, a design pattern is a general reusable solution to a commonly occurring problem in software design.
 - A design pattern is not a finished design that can be transformed directly into code.
 - It is a description or template for how to solve a problem that can be used in many different situations.
 - Patterns are the recurring solutions to the problems of design.
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When DPs were developed ?

- The idea originates from a book that organized implicit knowledge about how people solve recurring problems in building things:

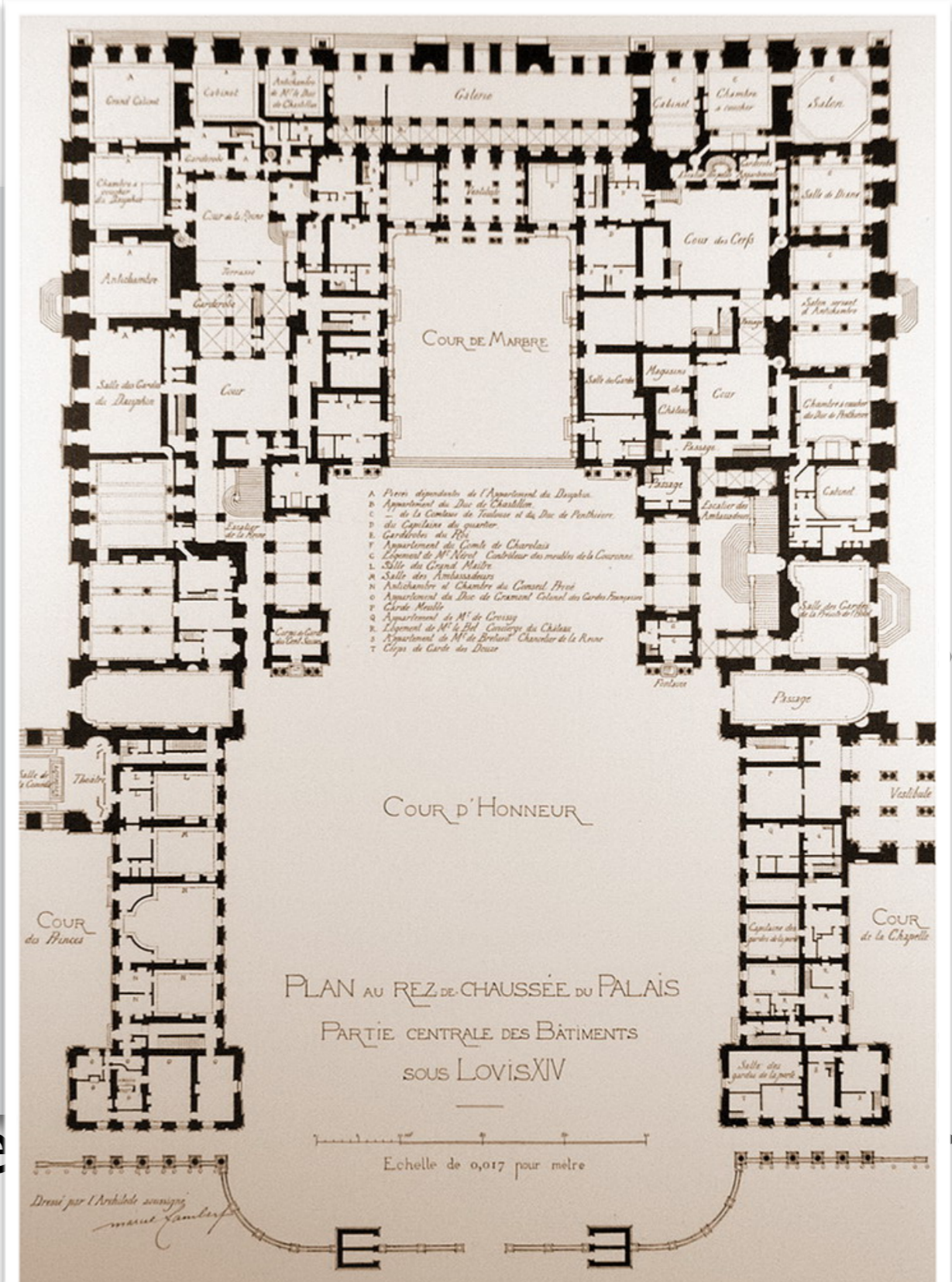
“Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice” - Prof. Charles Alexander



When DPs were developed ?

Example: Louis Le Vau, the original architect of Versailles, did not project a single corridor. Since 19th century the problem of moving from a room to another has been solved using corridors.

it the same way twice



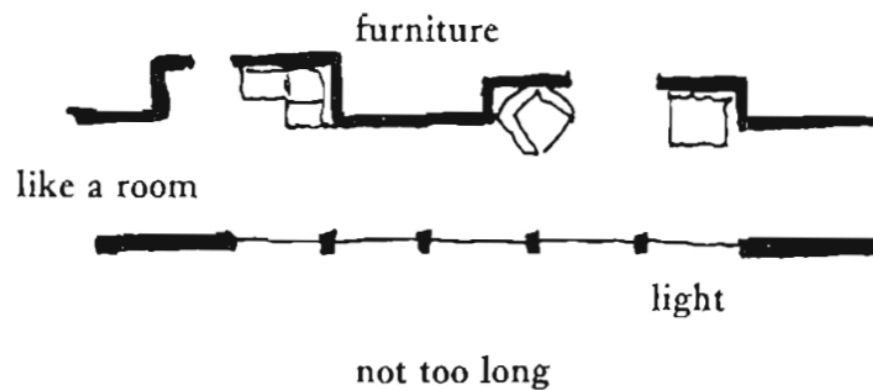
space envelope. (M. Spivack, "Sensory Distortion in Tunnels and Corridors," *Hospital and Community Psychiatry*, 18, No. 1, January 1967.)

When does a corridor become too long? In an earlier version of this pattern (*Short corridors in A Pattern Language Which Generates Multi-Service Centers*, CES, 1967, pp. 179-82), we have presented evidence which suggests that there is a definite cognitive breakpoint between long corridors and short halls: the evidence points to a figure of some 50 feet as a critical threshold. Beyond that, passages begin to feel dead and monotonous.

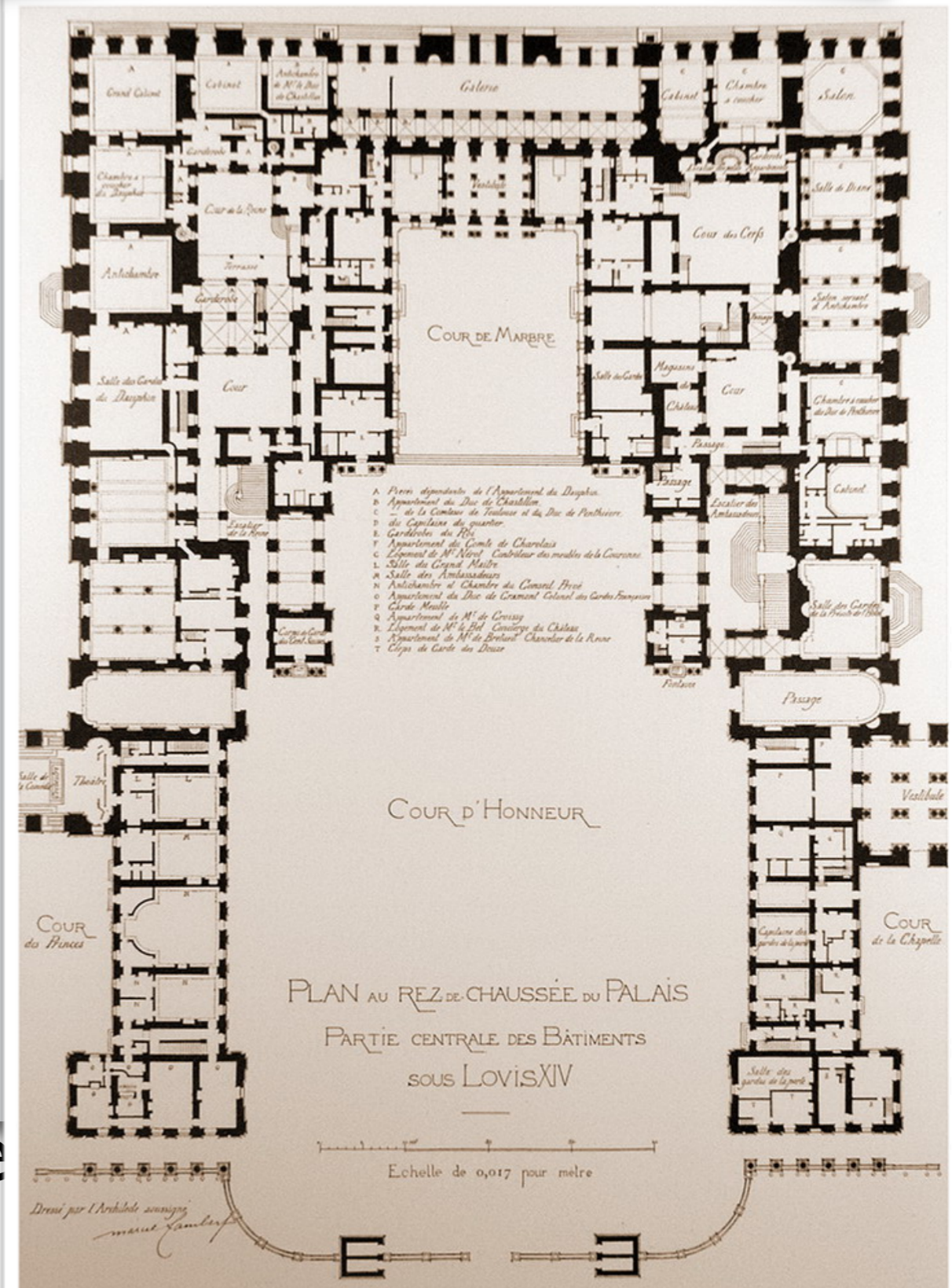
Of course it is possible to make even very long corridors in a human way; but if they have to be longer than 50 feet, it is essential to break down their scale in some fashion. For example, a long hall that is lit in patches from one side at short intervals can be very pleasant indeed: the sequence of light and dark and the chance to pause and glance out, breaks down the feeling of the endless dead corridor; or a hall which opens out into wider rooms, every now and then, has the same effect. However, do everything you can to keep the passages really short.

Therefore:

Keep passages short. Make them as much like rooms as possible, with carpets or wood on the floor, furniture, bookshelves, beautiful windows. Make them generous in shape, and always give them plenty of light; the best corridors and passages of all are those which have windows along an entire wall.



Alexander's design pattern for corridors





Why using design patterns ?

- Design patterns can speed up the development process by providing tested, proven development paradigms.
 - Design patterns provide general solutions, documented in a format that doesn't require specifics tied to a particular problem.
 - Design patterns allow developers to communicate using well-known, well understood names for software interactions.
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“Gang of Four” Pattern Structure

- Gang of Four (GoF): Gamma, Johnson, Helm, Vlissides
 - Authors of the popular “Design Patterns” book
 - A pattern has a **name**
 - e.g., the Command pattern
 - A pattern documents a recurring **problem**
 - e.g., issuing requests to objects without knowing in advance what’s to be requested or of what object
 - A pattern describes the core of a **solution**
 - e.g., class roles, relationships, and interactions
 - Important: this is different than describing a design
 - A pattern considers **consequences** of its use
 - Trade-offs, unresolved forces, other patterns to use
-



What patterns are not

- Design patterns ...
 - ... are not restricted to OOP
 - ... are not heuristics or abstract principles
 - ... are not new and/or untested solutions
 - ... are not a specific solution to a specific problem
 - ... are not a “silver bullet”
-



The iterator design pattern

- We have already seen an example of behavioural design pattern: the iterators of STL.
 - The basic idea of the iterator is that it permits the traversal of a container (like a pointer moving across an array). However, to get to the next element of a container, you need not know anything about how the container is constructed. This is the iterators job. By simply using the member functions provided by the iterator, you can move, in the intended order of the container, from the first element to the last element.
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Design patterns classification

- Design patterns were originally grouped into the categories Creational patterns, Structural patterns, and Behavioral patterns.
 - DPs were described using the concepts of:
 - **delegation:** is the concept of handing a task over to another part of the program. In object-oriented programming it is used to describe the situation wherein one object defers a task to another object, known as the delegate.
 - **aggregation:** is a way to combine simple objects or data types into more complex ones. Composited objects are often referred to as having a "has a" relationship. In composition, when the owning object is destroyed, so are the contained objects. In aggregation, this is not necessarily true.
 - **consultation:** is when an object's method implementation consists of a message send of the same message to another constituent object.
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Types of design patterns - I

Creational design patterns

- This design patterns is all about class instantiation. This pattern can be further divided into class-creation patterns and object-creational patterns.
 - While class-creation patterns use inheritance effectively in the instantiation process, object-creation patterns use delegation effectively to get the job done.
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Types of design patterns - 2

Structural design patterns

- This design patterns is all about Class and Object composition. Structural class-creation patterns use inheritance to compose interfaces.
 - Structural object-patterns define ways to compose objects to obtain new functionality.
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Types of design patterns - 3

Behavioral design patterns

- This design patterns is all about Class's objects communication. Behavioral patterns are those patterns that are most specifically concerned with communication between objects.
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Some patterns

- In this and in the next lectures we'll see:
 - Adapter - structural - Match interfaces of different classes
 - Observer - behavioral - A way of notifying change to a number of classes
 - Factory - creational - Creates an instance of several families of classes
 - Singleton - creational - A class of which only a single instance can exist
-



Programming idioms

- Idioms are reoccurring solutions to common programming problems.
 - Idioms are low-level patterns specific to a programming language. Design patterns are high-level and language independent.
 - During implementation you look for idioms. During design you look for patterns.
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We have already seen them...

- include guard and RAll are programming idioms
 - Another example: the interface class
 - if we are more interested in interface inheritance than implementation inheritance we design the interface using a class composed only by pure virtual public methods
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Idiom: interface class

```
class Shape // An interface class
{
    public:
        virtual ~Shape();
        virtual void move_x(int x) = 0;
        virtual void move_y(int y) = 0;
        virtual void draw() = 0;
//...
};

class Line : public Shape
{
    public:
        virtual ~Line();
        virtual void move_x(int x); // implements move_x
        virtual void move_y(int y); // implements move_y
        virtual void draw(); // implements draw
    private:
        point end_point_1, end_point_2;
//...
};
```



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//...
};
```

In Java we would use an
Interface



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Remind the virtual destructor !

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private:
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//...
};
```

Remind the virtual destructor !

The classes that extend Shape are not dependent each other



Adapter pattern

Class and Object Adapter



Class and Object Adapter

- Review the pattern we have already seen in the slides on inheritance: the class adapter and see another version of the pattern, the object adapter
 - The Adapter pattern converts the interface of a class into another interface the clients expect.
Adapter lets classes work together that could not otherwise because of incompatible interfaces.
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Adapter pattern

- Problem
 - Have an object with an interface that's close to but not exactly what we need
 - Context
 - Want to re-use an existing class
 - Can't change its interface
 - Impractical to extend class hierarchy more generally
 - Solution
 - Wrap a particular class or object with the interface needed (2 forms: class form and object forms)
 - Consequences
 - Implementation you're given gets interface you want
-

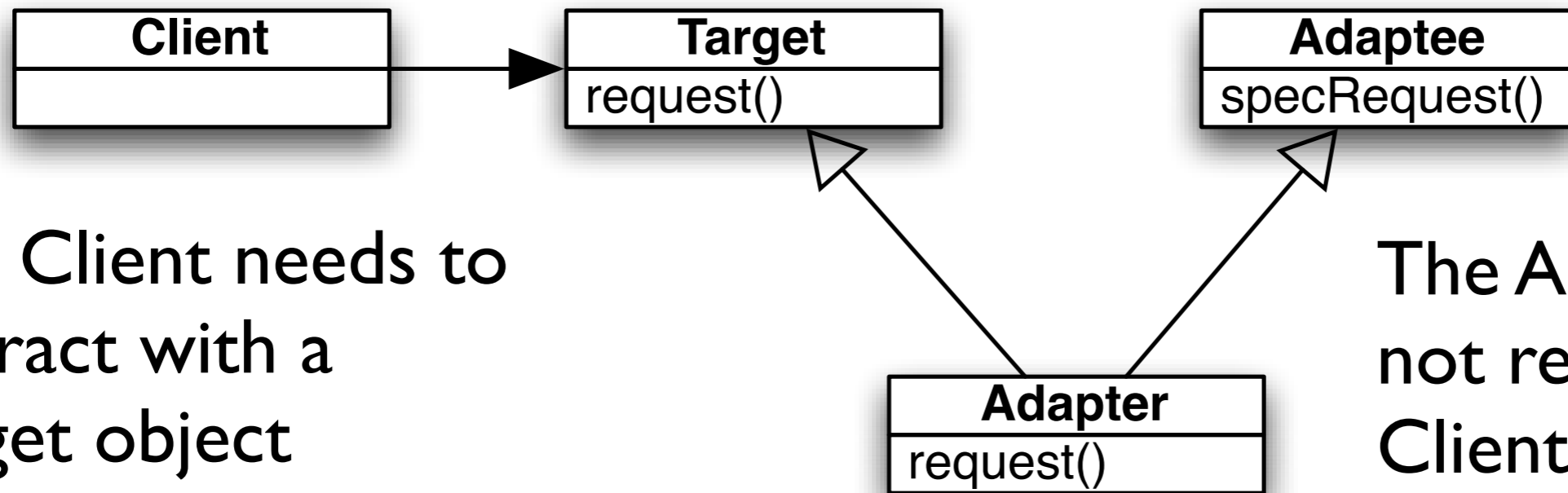


Class Adapter

- A class (Adapter) adapts the interface of another class (Adaptee) to a client, using the expected interface described in an abstract class (Target)
 - Uses multiple inheritance, along with abstract class, virtual methods and private inheritance.
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Class Adapter UML class diagram



The Client needs to interact with a Target object

The Adaptee could not respond to Client because it does not have the required method

The Adapter lets the Adaptee to respond to request of a Target by extending both Target and Adaptee



Class Adapter example

```
class Adaptee {
public:
    float getAlpha() {
        return alpha;
    };
    float getRadius() {
        return radius;
    };
private:
    float alpha;
    float radius;
};

class Target {
public:
    virtual float getX() = 0;
    virtual float getY() = 0;
};
```

```
class Adapter : private Adaptee, public Target {
public:
    virtual float getX();
    virtual float getY();
};
float Adapter::getX() {
    return
        Adaptee::getRadius()*cos(Adaptee::getAlpha());
}
float Adapter::getY() {
    return
        Adaptee::getRadius()*sin(Adaptee::getAlpha());
}
```

The Client can't access Adaptee methods because Adapter has obtained them using private inheritance

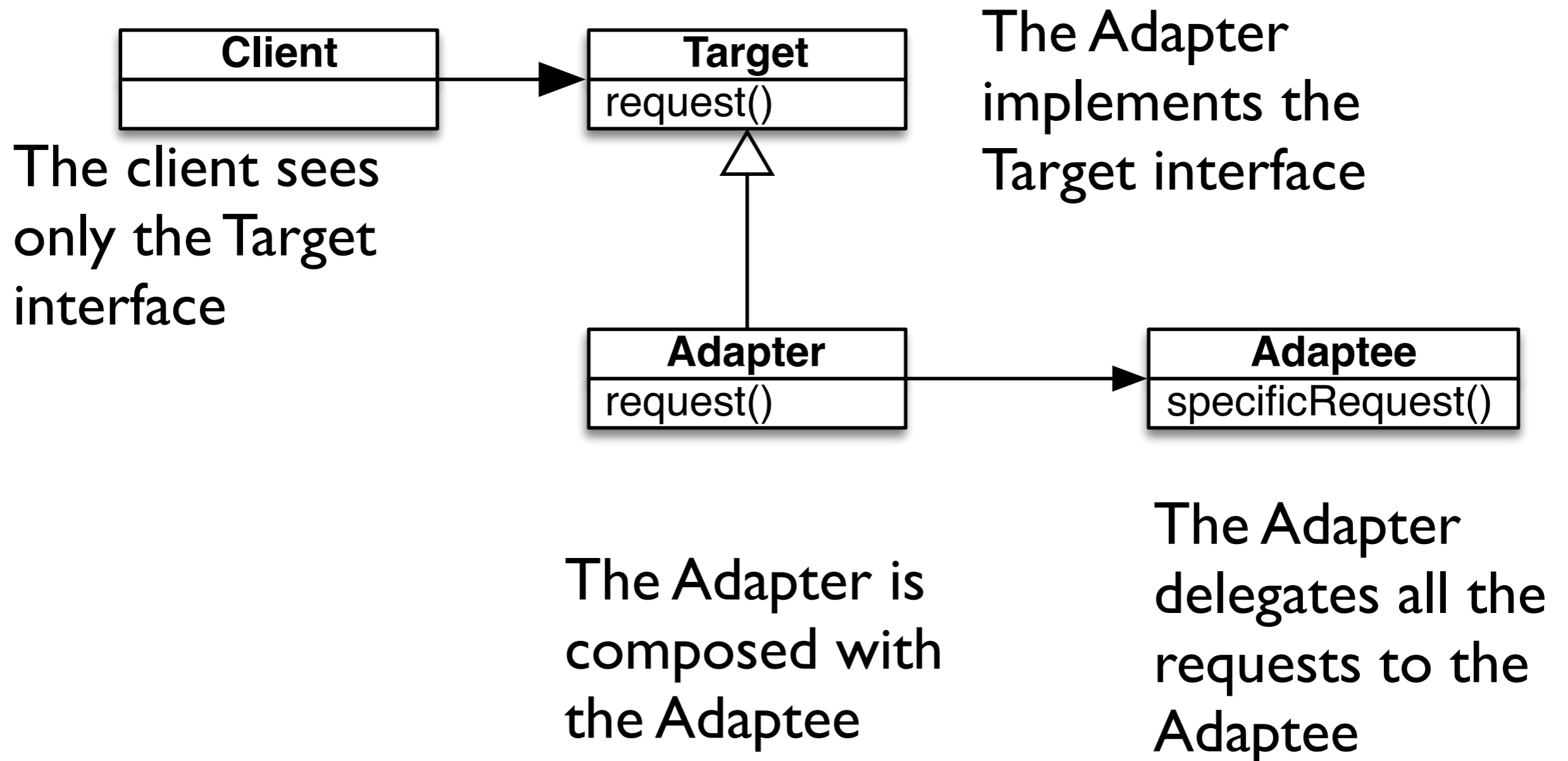


Object Adapter

- Does not use multiple inheritance but uses composition to adapt the adaptee class:
 - it can adapt also subclasses of the adaptee (unlike the Class Adapter)
 - requires to reimplement the adaptee, thus require more coding (unlike the Class Adapter)
 - The adapter delegates to the adaptee the requests of the clients
-



Object Adapter UML class diagram





Object Adapter example

```
class Duck {  
    public: virtual ~Duck() = 0 { }  
    public: virtual void fly() const = 0;  
    public: virtual void quack() const = 0;  
};
```

```
class MallardDuck : public Duck {  
    public: void fly() const {  
        cout << "I'm flying" << std::endl;  
    }  
    public: void quack() const {  
        cout << "Quack" << std::endl;  
    }  
};
```

```
class Turkey {  
    public: virtual ~Turkey() = 0 { }  
    public: virtual void gobble() const = 0;  
    public: virtual void fly() const = 0;  
};
```

```
class WildTurkey : public Turkey {  
    public: void fly() const {  
        cout << "I'm flying a short  
distance" << endl;  
    }  
    public: void gobble() const {  
        cout << "Gobble gobble" << endl;  
    }  
};
```



Object Adapter example

```
class TurkeyAdapter : public Duck {
private: const Turkey* turkey;
public: TurkeyAdapter( const Turkey* turkey ) : turkey( turkey ) { }
public: void fly() const {
    for( int i = 0; i < 5; i++ ) {
        turkey->fly();
    }
}
public: void quack() const {
    turkey->gobble();
}
};
```

```
public: void quack() const {
    cout << "Gobble gobble" << endl;
}
};
```

```
class Turkey {
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public: void quack() const {
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};
```

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class Turkey {
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Here's the composition !
Any class extending Turkey may be adapted because of the IS_A relationship



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Here's the delegation

Here's the composition !
Any class extending Turkey may be adapted because of the IS_A relationship

```
public: void quack() const {
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};
```

```
class Turkey {
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};
```

Here's the delegation

Here's the composition !
Any class extending Turkey may be adapted because of the IS_A relationship

```
void testDuck( const Duck* duck ) {
    duck->quack();
    duck->fly();
}

...
MallardDuck* duck = new MallardDuck();
WildTurkey* turkey = new WildTurkey();
Duck* turkeyAdapter = new TurkeyAdapter( turkey );
testDuck( duck );
testDuck( turkeyAdapter );
...
```



Reading material

- M. Bertini, “Programmazione Object-Oriented in C++”,
parte II, cap. 1 + 2



Credits

- These slides are (heavily) based on the material of:
 - Aditya P. Mathur, Purdue University
 - Dr. Aaron Bloomfield, University of Virginia
 - Fred Kuhns, Washington University
 - Glenn Puchtel
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