Object Oriented Programming

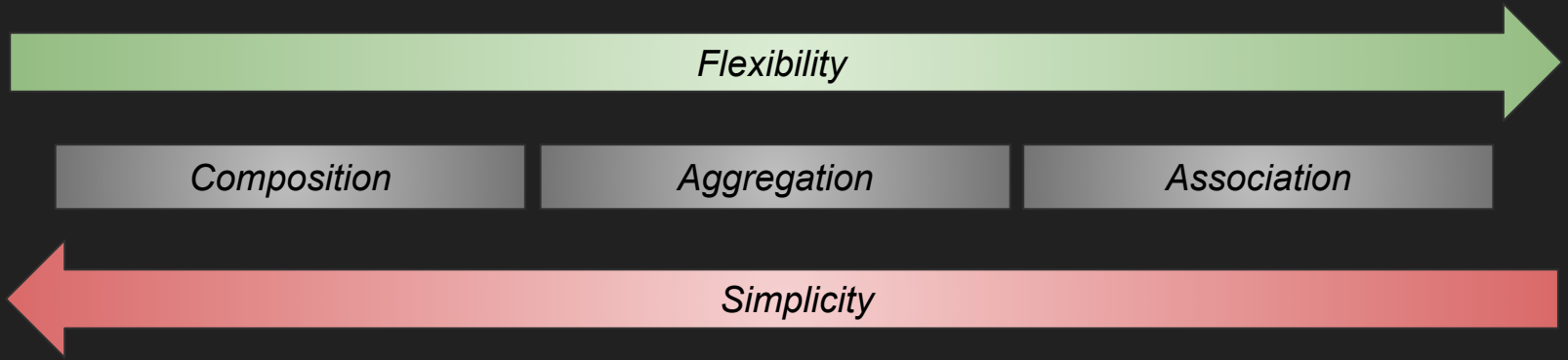
Object Relations & Interactions

Object relations

- Instance level relations
  - Composition
  - Aggregation
  - Association
- Class level relations
  - *Inheritance*

Instance level relations: Overview

- ***Composition*** is the strongest relation - *ownership (***has-a***)* with *lifecycle dependency*. Simplest relation, but no flexibility.
- ***Aggregation*** is weaker ownership (**has-a)** without *lifecycle dependency*.
- ***Association*** is the weakest relation of the three. **No** ownership, **no** *lifecycle dependency,* only knowledge / loose usage of the *associated* object(s).



Instance level relations: *Composition*

- ***Composition*** is the strongest ownership relation
- It is never **shared** - the owned object belongs exclusively and solely to the owner
- There is lifecycle dependency: destroying the owner in a *composition* relation typically means destroying the *owned object(s).*
- However, usually the owned object cannot be changed, replaced, reused outside of its exclusive owner. Usually it cannot be retained after owner's death

```
class Cup
{
public:
    Cup();
    Cup(double, double, const Picture&);
    Cup(const Cup&);
    ~Cup();

    void fill(const double);
    double getQuantity() const;
private:
    double quantity;
    double capacity;
    Picture picture;
};
```

Instance level relations: *Aggregation*

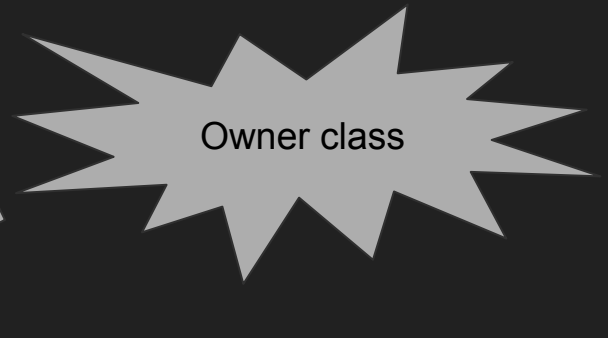
- ***Aggregation*** is weaker ownership relation
- It can be shared *(but not always is).* If shared, the owned object potentially belongs to multiple owners.
- There is no *lifecycle dependency:* the owned object can outlive its current owner. Often the owner can be created *empty* and receive owned objects later.
- The programmer often needs to take care of *lifecycles* of both owner and owned objects separately. He must also prevent the risk of calling into already dead object. *Resource leaks* must be prevent too.
- The owned object typically can be *changed, replaced, reused* outside of the current owner.

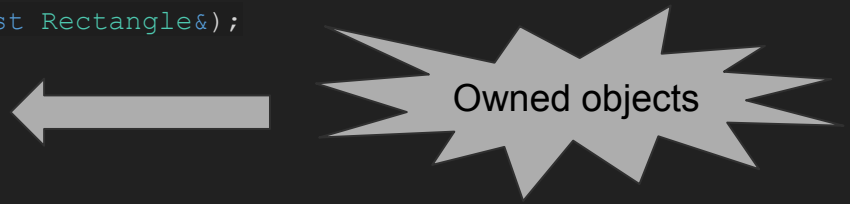
```
class Rectangle
{
private:

   struct Point
   {
       double x;
       double y;
   };

   Point a;
   Point b;
};

class SVG
{
public:
   void addRectangle(const Rectangle&);
   bool removeRectangle(const Rectangle&);
private:
   Rectangle* rectangles;
};
```

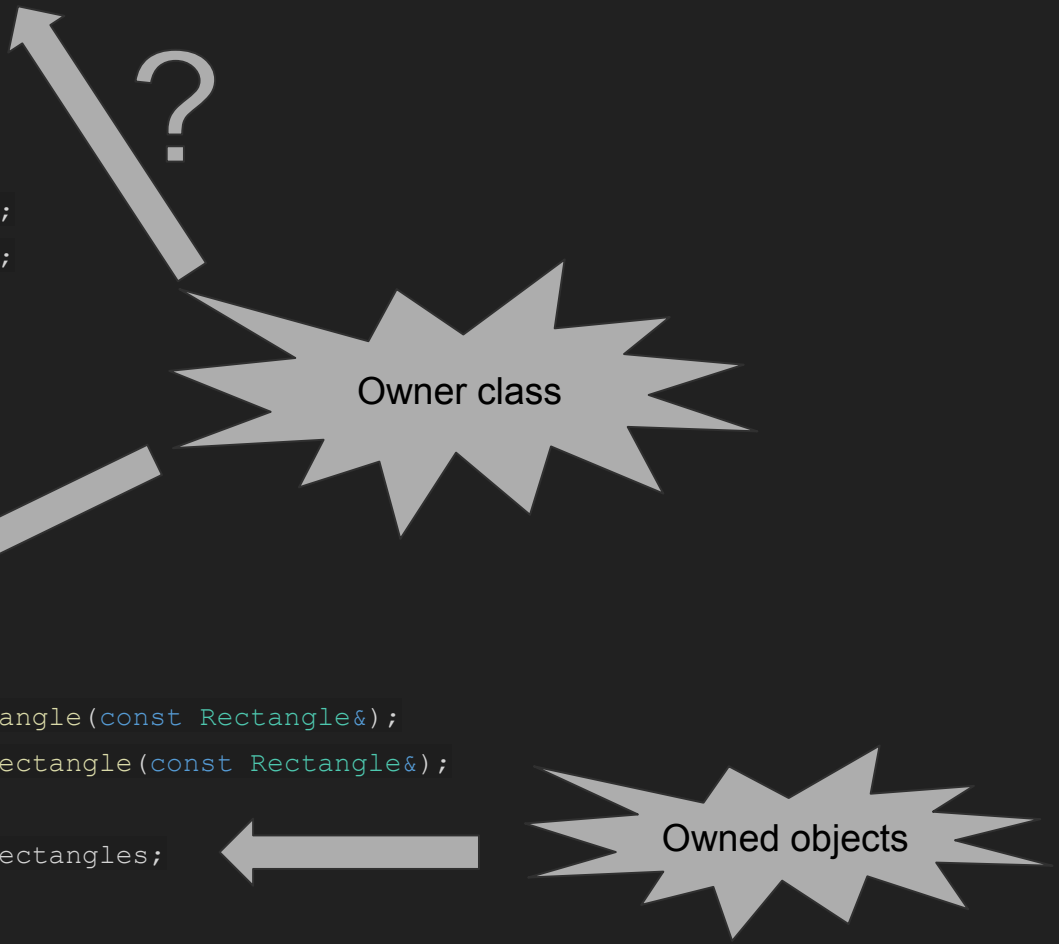


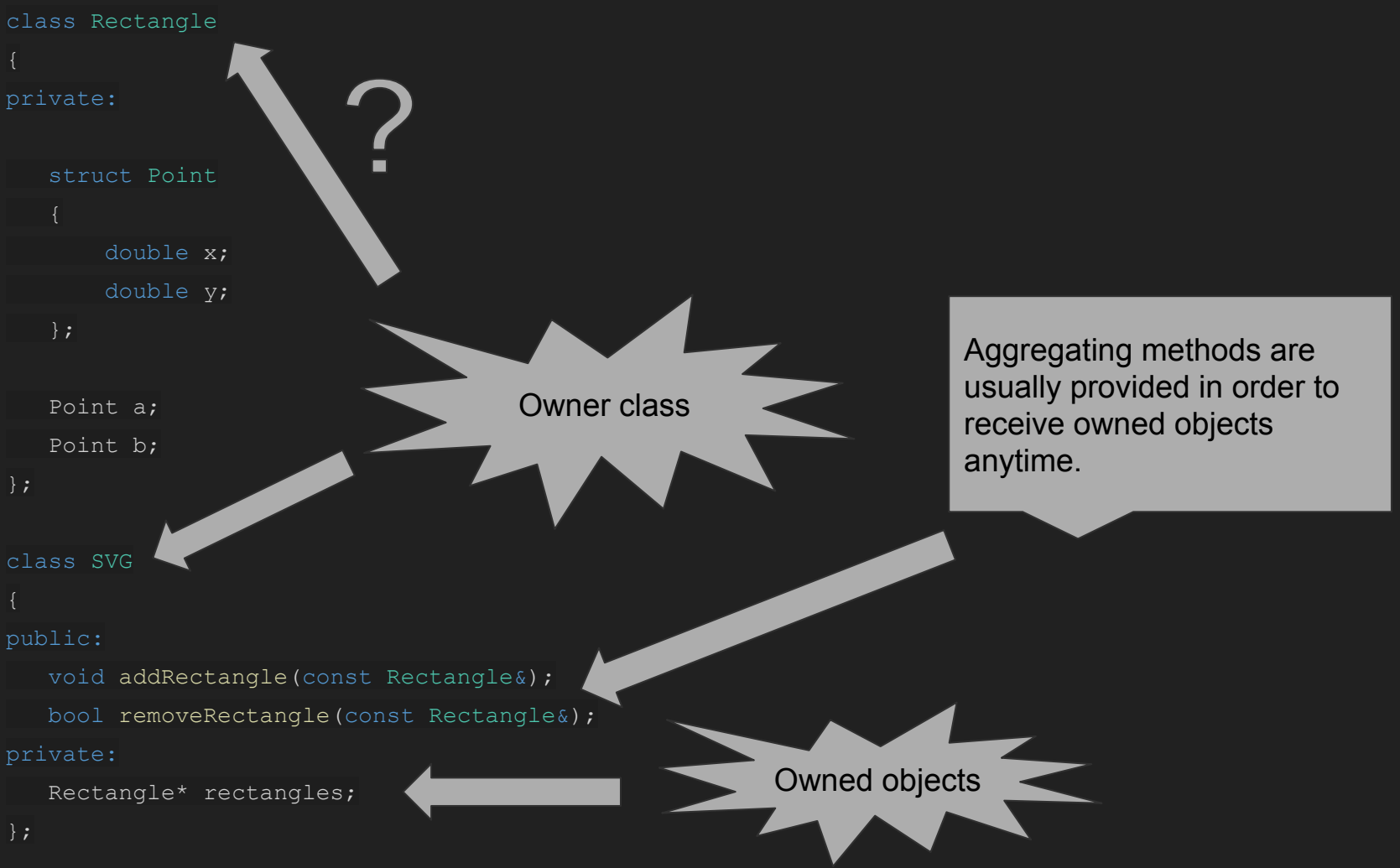


```
class Rectangle
{
private:
   struct Point
   {
       double x;
       double y;
   };

   Point a;
   Point b;
};

class SVG
{
public:
   void addRectangle(const Rectangle&);
   bool removeRectangle(const Rectangle&);
private:
   Rectangle* rectangles;
};
```




class Rectangle
{
private:
struct Point
{
double x;
double y;
};
Point a;
Point b;
};
?
Owner class
Aggregating methods are usually provided in order to receive owned objects anytime.
class SVG
{
public:
void addRectangle(const Rectangle&);
bool removeRectangle(const Rectangle&);
private:
Rectangle* rectangles;
};
Owned objects

Instance level relations: *Association*

- ***Association*** is weakest relation of the three. It is **no ownership** at all.
- There is no *lifecycle dependency.* An object just knows the type of another object and collaborates with it (request a service).
- Basically, an ***objA*** of class ***A*** receives a message (has a method call) with ***objB*** of class ***B*** passed as an argument. Then ***objA*** uses ***objB*** to perform a job and returns.

```
class Seller;

class Customer
{
public:
   void buyGoods(const Seller& seller);
};
```

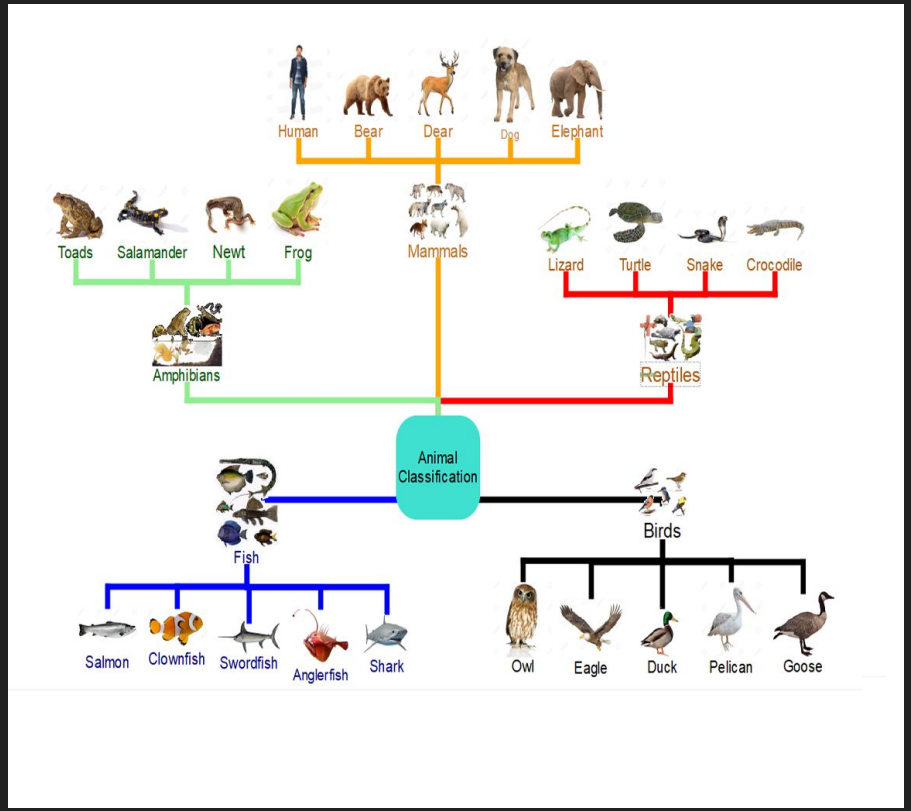
Inheritance & Generalization

Inheritance, Subtyping, Generalization - Basics

- ***class level*** type of relation (relation between ***entire classes***, not between instances/objects)
- Defines an "***is-a"*** relationship between classes
- Used to *classify* classes into larger groups, which are also *classes (what ??)*
  - A **Mamal** "***is-an"*** **Animal** (both **Mamal** and **Animal** are classes)
  - Deeper hierarchies are possible: a **Human "*is-a"* Mamal** which ***"is-an"*** **Animal**
- ***Each descendent (i.e. the Human class) receives members of its base class(es) (i.e. Mamal and Animal)***

Inheritance, Subtyping, Generalization contd.

Generalization



Inheritance

Inheritance/Generalization examples

- Which of the following examples correspond to ***is-a*** relationship, and which don’t?

```
class Phone;
// is-a
class Display;
```

```
class Circle;
class Rectangle;
// is-a
class Shape;
```

```
class Car;
// is-a
class Vehicle;
```

```
class SVG;
// is-a
class Rectangle;
```

Inheritance/Generalization examples

- Which of the following examples correspond to ***is-a*** relationship, and which don’t?

```
class Phone;
// has-a
class Display;
```

```
class Circle;
class Rectangle;
// is-a
class Shape;
```

```
class Car;
// is-a
class Vehicle;
```

```
class SVG;
// has-a
class Rectangle;
```

Inheritance/Generalization examples contd.

Consider the following example: What is not fine here?

```
class Vehicle {
public:
   Vehicle();
   Vehicle(const char*, const char*,
                        const double&);
   Vehicle(const Vehicle&);
   Vehicle& operator=(const Vehicle&);
   ~Vehicle();
   void fuel(const double&);
private:
   char* model;
   char* registrationPlate;
   double fuelLiters;
};
```

```
class Car {
public:
   Car();
   Car(const char*, const char*, const double&, const unsigned&);
   Car(const Car&);
   Car& operator=(const Car&);
   ~Car();
   void fuel(const double&);
   unsigned getNumberOfSeats() const;
private:
   char* model;
   char* registrationPlate;
   double fuelLiters;
   unsigned numberOfSeats;
};
```

Inheritance/Generalization examples contd.

Consider the following example:

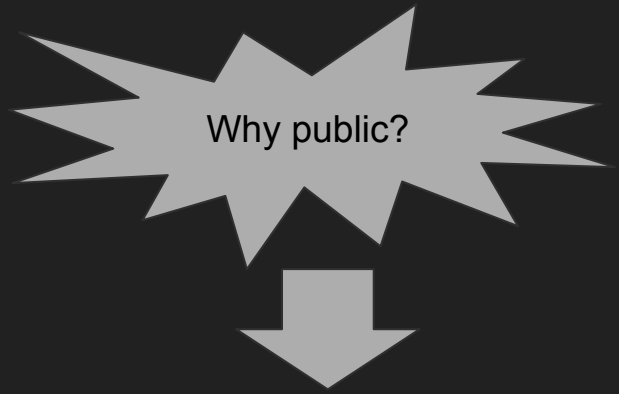
```
class Vehicle {
public:
   Vehicle();
   Vehicle(const char*, const char*,
                        const double&);
   Vehicle(const Vehicle&);
   Vehicle& operator=(const Vehicle&);
   ~Vehicle();
   void fuel(const double&);
private:
   char* model;
   char* registrationPlate;
   double fuelLiters;
};
```

```
class Car : public Vehicle
{
public:
   unsigned getNumberOfSeats() const;
private:
   unsigned numberOfSeats;
};
```

Inheritance/Generalization examples contd.

Consider the following example:

```
class Vehicle {
public:
   Vehicle();
   Vehicle(const char*, const char*,
                        const double&);
   Vehicle(const Vehicle&);
   Vehicle& operator=(const Vehicle&);
   ~Vehicle();
   void fuel(const double&);
private:
   char* model;
   char* registrationPlate;
   double fuelLiters;
};
```

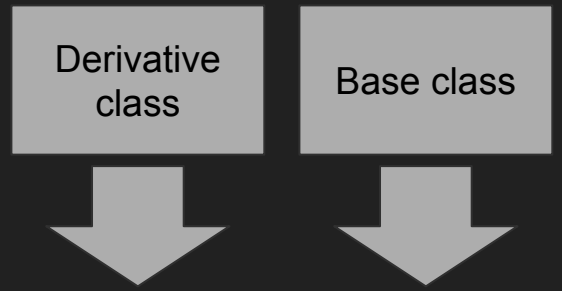



```
class Car : public Vehicle
{
public:
   unsigned getNumberOfSeats() const;
private:
   unsigned numberOfSeats;
};
```

Inheritance/Generalization examples contd.

Consider the following example:

```
class Vehicle {
public:
   Vehicle();
   Vehicle(const char*, const char*,
                        const double&);
   Vehicle(const Vehicle&);
   Vehicle& operator=(const Vehicle&);
   ~Vehicle();
   void fuel(const double&);
private:
   char* model;
   char* registrationPlate;
   double fuelLiters;
};
```




```
class Car : public Vehicle
{
public:
   unsigned getNumberOfSeats() const;
private:
   unsigned numberOfSeats;
};
```

Inheritance types and access modifiers

Access modifier / Inheritance type	public	protected	private
public	public	protected	private
protected	protected	protected	private
private	private	private	private

Inherited objects construction & destruction

- By default the base class **default constructor** is called every time a derivative object is created.
- If we want to call another *(non-default) Base class* constructor from the derivative class, we must do it explicitly with *Base::Base(params | Base&);*
- Calling *Base class' operator=* from the derivative class: *Base::operator=(derivativeObj);*
- Destruction of derived class object - by default calls *Base class destructor*
- ***Construction & destruction order of derived classes objects explanation***

Inheritance chaining

- Deeper hierarchies is possible in c++
  - ***A*** inherits from ***B*** inherits from ***C …*** inherits from ***Z***
- Dealing with more than *3* levels of inheritance becomes hard to understand, hard to maintain, less flexible and so on

- When there is ***two*** possible relations between ***two*** classes (*objects*), ***always favour composition / aggregation over inheritance***
  - However, we rarely consider more than one logical relation between classes(objects)