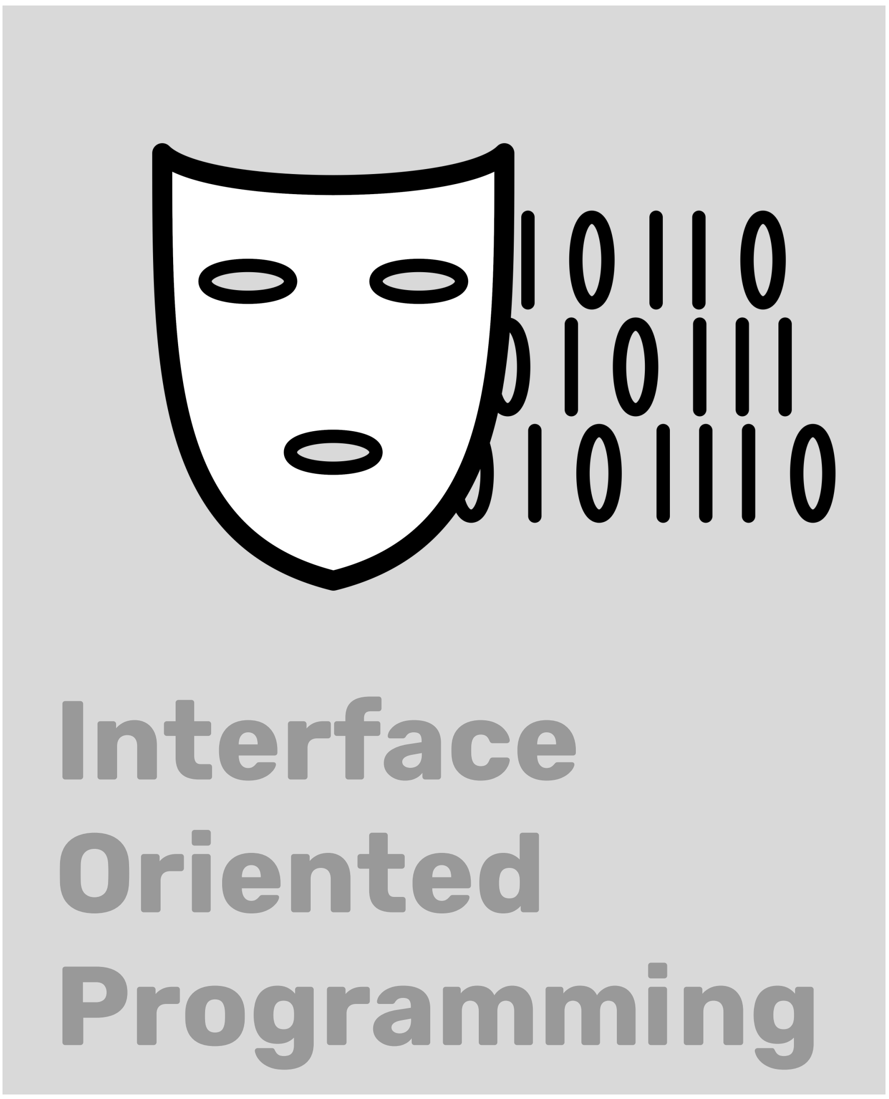
PHATASS Studios

IOP: An introduction

Interface Oriented Programming

A SOLID-based software development architecture revolving around heavy use of representative, minimal contracts in order to maximize a codebase's maintainability.



IOP, Interface Oriented Programming

> Greetings!

Hi! I'm Héctor, father of the upcoming PHATASS Studios and programmer since I was 16. Over the last couple of years I've been designing and refining a design paradigm I've come to name **"Interface Oriented Programming"**, or **IOP.** It's a set of ideas and parameters designed around enforcing a very **clean** code **architecture**.

Now I'd like to share it with you.

While the vast majority of my experiments have been in C#, the ideas contained herein should apply to any interface-capable object-oriented language. My favourite candidate would be TypeScript.

A note on examples: Examples are based on C# but the general ideas herein should apply to any interface-apt language.

> What's an interface? The strengths of not knowing too much.

Simply put, an **interface is a contract**: When an object implements an interface it agrees to do what the interface says it must do.
It can be requested **whatever the interface dictates it can be requested**, and when requested something through an interface it **must do exactly that and only that** as defined by the interface, no side effects.

E.G.: For a car to be considered a proper vehicle, it must fulfill all of a vehicle's capabilities: you can put things and/or people in it, and move around.

```
public interface IVehicle
{
        //We define the type and accessibility of a Contents property
        //Offers the client access to the vehicle cargo/passengers
        IList<IThing> Contents { get; } //Read-only

        //Method with a defined return type and parameter list
        //we can make the vehicle go somewhere - taking its cargo with it
        void TravelTo (IPlace destination);
}

//Both Car and Bike implement IVehicle
public class Car : IVehicle {/*...*/}
public class Bike : IVehicle {/*...*/}
```

Notice how **interfaces** themselves **only refer** to other **interfaces**, **never classes**.

Obviously a car fits more people and has a spacious trunk, whereas a bike fits only you and maybe a small basket.
Regardless of those petty differences in **implementation** details, your car and your bike perfectly **fulfil** the **IVehicle contract**, the very same way a spaceship does. They both have contents and can go places taking their content with them.

Using a proper naming convention is capital, as usual. I can't stress enough how important it is to distinguish interfaces by name - I prefer prepending an "I" to represent it is an **I**nterface. This way, if you somewhere mistakenly refer to something that's **NOT** an interface you can quickly notice and fix it.

Interfaces allow us to easily separate logical structure from implementation details.

> IOP's core: you ONLY know about interfaces.

Interface Oriented Programming is an **interface-first** analysis and design paradigm that revolves around **very heavy** use of **interfaces**. The core Philosophy boils down to a single phrase:

You think, analyze, and design ONLY with interfaces.

Only afterwards will you program concrete components that **implement** said **interfaces**. This offers **GREAT flexibility**.

Imagine you wake up in the morning and walk up to your parking lot expecting to climb into your **car** and drive to work, as usual. You'll be in a lot of trouble if that morning your daughter took your car, leaving instead your **bike** for you to go to work.

You just can't climb on top of a **bike**, grab the wheel, step on the gas, and drive as if it was the **car** you expected.

```
//This breaks…
Car myRide = new Bike();

//...but it's good that it breaks because this wouldn't work either
myRide.gear = 1;            //Your city bike may or may not have a gear plate
myRide.gasPedal = true;     //But certainly it doesn't have a gas pedal
```

If, on the other hand, you wake up, go to the **IVehicle** in your parking lot, and use it to travel to your workplace, your routine will work without a hitch, regardless of it being with a car or with a bike.

```
IVehicle myRide = garage.GetVehicle();

myRide.Contents.Add(myThings);
myRide.Contents.Add(me);

myRide.TravelTo(workplace);
```

Put things in vehicle. Put myself in vehicle. Go to work. **Simple** and functional.

Heck, worst-case-scenario, if there is **nothing** in your parking lot, you could even consider **yourself** a IVehicle (you can carry things in your pockets, and walk to places), use yourself as a fall-back mechanism, and just TravelTo() your workplace using your natural walking capabilities, no fuss, no muss.

By completely removing our knowledge of implementation details and replacing EVERYTHING with interfaces, we make the process a lot more robust AND simpler.

> The evil temptation of Public class members

The **most important** rule in POI is the one that, not only single-handedly enables proper separation of responsibilities across your project, also ensures your analysis schemes are simple, straightforward, and easy to understand:

No object must know anything about the implementation details of another object.

Object meaning any concrete implementation of a class/struct/whatever.
That means you can never access the members of another class or struct, and in fact:

Any piece of code should only know about itself, and about required interfaces.

The easiest and safest way to perfectly achieve this is as simple as:

No object should expose any non-interface public member.

This way you can completely guarantee your code only flows through appropriately defined and analyzed interfaces. Absolutely no stealth code accessing things that *maybe* it should not.

But why do I need interfaces for that? I already program this way by properly using public/private memberships across my class hierarchy!

Of course you do! I haven't invented anything you couldn't do before. But **IOP** lets you analyze your codebase in a way that **forces** you to properly **insulate responsibilities** before you even begin to analyze and design your classes.

Think only with interfaces.

> Constrain yourself to gain freedom: Analize with IOP, implement however you please

Note how most included examples forgo any implementation details, defining **only interfaces** and their **relationships**.
This is intentional. Try to notice how entirely **ignoring implementation** details and **focusing** on the **logical relationships** between abstract designs (**interfaces**) makes every problem way **faster** and **easier** to grasp.

This is why **Interface Oriented Programming** or **IOP** is a programming paradigm **focused** exclusively in the **analysis** of the **relationships** between **objects.**

IOP offers absolutely **no** advice on **implementation** decisions, and in fact strongly advises to entirely **ignore implementation** details while designing object relationships.

When planning, focus on *what* you need to do, NOT on *how* to do it.

> Interface Inheritance

Interfaces can inherit from as many other interfaces as they want. This is actually referred to as an interface *implementing* another interface

Interface implementation trees are way more **powerful and flexible** than Class inheritance trees as far as **codebase analysis and design** is concerned:

- An interface can **inherit from multiple others**, without concerns for fragile resolution ordering.
- Interfaces let you **properly separate** the various aspects of a specific problem/resolution set in order to **re-use** them.
- Interfaces **force you to think abstractly** about their relationships, lacking implementation. This leads to a **way more maintainable** codebase.

E.G.: in our example, vehicles have a content.
However, every consideration about keeping and exposing a modifiable bunch of contents, is completely independent from the notion of a vehicle.

The car's **trunk** is **independent** from its **engine**.

We can and should **separate those responsibilities** across multiple interfaces:

```
//IContainer inherits (implements) system ICollection interface for even more flexibility
public interface IContainer : ICollection
{
 IList<IThing> Contents { get; }
}

//IMovable defines any form of object that can move by itself
public interface IMovable
{
 void MoveTo (IPlace destination); //Renamed TravelTo as MoveTo so it more
appropriately fits any form of movable item
}

//IVehicle definition is now way neater and clearer
public interface IVehicle : IMoveable, IContainer
{}
```

We must always properly separate the responsibilities of our interfaces, and what problems and sub-problems they represent.

> Polymorphism through Interfaces

Since **interfaces represent a contract**, when communicating exclusively through interfaces it is tremendously **easy** and natural to **replace an object** that **fulfills a contract** with **any other object** as long as it **fulfills the same contract.**

In our initial example we could use our **bike** as a perfect **replacement** for our **car** solely thanks to the use of **interfaces**:

- Car **fulfills** the contract **IVehicle**
- Bike **fulfills** the contract **IVehicle**
- We can **use any IVehicle**, instead of just a specific implementation.

In this manner we **polymorph** specific **implementations** into a common **interface** we can refer to without knowledge about implementation. Thanks to this, it is trivial to change the vehicle we use at any time.

Another form of interface polymorphism is **casting** an object or interface to **a specific interface** representing a **specific responsibility.**

E.G.: Before a big trip, we may want to pack our things into the car the day before.
We generally consider our **car** an **IVehicle**, and we could store things into it directly. But for the sake of just packing our things, we should treat our **car** as an **IContainer** for simplicity:

- Since IVehicle inherits or implements IContainer, **every IVehicle is an IContainer**.

- **IContainer** represents the **specific problem** of **storing** items. This means it's more adequate to expect to **store our things** into an **IContainer** rather than an IVehicle.

- This way, we could then easily **swap** the **target IContainer** from our car to any **other** IContainer.

Thanks to this, we could use a suitcase as a proxy IContainer, put our things into it, then just put our suitcase into the car for the trip. Sounds way neater than just tossing our underwear all over the back seats. It's also easier to unpack.

We could even **re-use** the very same steps we took to store our things anywhere else.
We might use a box in the basement as an IContainer to protect our stuff while we paint the house.

When referencing an interface, try to pick the one within the interface tree most adequate to the problem at hand.

> Generic types are your friend, generic constraints are your savior.

When defining an **interface**, we need to give every member a **compile-time-resolvable** type.
This means the type of every member needs to be known at compile time, which is necessary for your interfaces to be **type-safe**.
This *would* mean every member needs to be given a rigid, un-changeable type, disallowing the easy construction of flexible structures.

```
public interface ITrashCan
{
 //Our trash method is designed to accept ANY IThing
 //This forbids any form of ITrashCan accepting only a specific type of object
 //No recycling bins - we would be able to dump anything into it.
 void Dump (IThing garbage);
}

public class RecyclingBin : ITrashCan {/*...*/}

ITrashCan recyclingBin = new RecyclingBin();
IThing nonRecyclable = new NonRecyclable();

//our recycling bin erroneously lets us trash any IThing, even if it can’t be recycled
recyclingBin.Dump(nonRecyclable);
```

Cue the ***generic types***. Generic types allow us to define one or more types that instead of being defined within the interface, will be passed to the interface during compile-time.

```
//Now, any time we implement the ITrashCan interface  we’ll provide a type
//This type will be represented as TGarbage
//During execution, any instance of TGarbage will be replaced with the given type
public interface ITrashCan <TGarbage>
{ void Dump (TGarbage garbage); }

//IRecyclingBin will take any form of IRecyclable
public interface IRecyclingBin : ITrashCan<IRecyclable>
{}

public class RecyclingBin : IRecyclingBin {/*...*/}

IRecyclingBin recyclingBin = new RecyclingBin();
IRecyclable recyclable = new Recyclable();
IThing nonRecyclable = new NonRecyclable();

//our Genericly-typed Recycling bin now accepts only recyclable items
recyclingBin.Dump(recyclable);  //Ok
```

```
        recyclingBin.Dump(nonRecyclable);  //compile-time error, warning us very early of
our mistake
```

Now that we can delimit types for our interfaces at compile time, it becomes way easier to **maintain flexibly-typed inheritance trees**, as any typing errors are immediately reported by the compiler, instead of letting potential errors pass on to subsequent development phases.

But ultimate power can be achieved with **generic constraints**.

In our previous example, we defined a base ITrashCan<TGarbage> interface taking a generic type.
However, this allows us to make ITrashCans for anything - even if it's not garbage.
What if we want to ensure TGarbage is a type that always corresponds to any form of ITrash?
Generic constraints let us **mandate** that a generic type will always **inherit from a specific type**:

```
public interface ITrash {}
public interface IRecyclable : ITrash {}
public interface IGlass : IRecyclable {}
public interface IPaper : IRecyclable {}

//now, TGarbage must always implement ITrash
public interface ITrashCan <TGarbage>
 where TGarbage : ITrash
{ void Dump (TGarbage garbage); }

//A generic IRecyclingBin accepting only recyclable items
public interface IRecyclingBin <TRecyclable> : ITrashCan<TRecyclable>
 where TRecyclable : IRecyclable
{}

//concrete implementations of IRecyclingBin separating accepted residues by type
public interface IGlassRecyclingBin : IRecyclingBin<IGlass> {}
public interface IPaperRecyclingBin : IRecyclingBin<IPaper> {}
```

As you can see, you can even use generic parameters across inheritance trees in order to offer a progressively more specialized interface through its implementation tree.

Generic types are very powerful as they offer flexibility alongside type-safety.

> Interface Implicit vs Explicit implementation (Softcore vs Hardcore IOP)

When implementing an interface, the simplest and **easiest** way to define the public interface methods is through **implicit implementation**: public class members matching an interface member in name and signature are **automatically** recognized as that interface's signature.

Imagine we have an interface defining a way to interact with our stereo system:

```
public interface IAudioPlayer
{
 void Play ();  //Play a music song
}

public class BoomBox : IAudioPlayer
{
 //this parameterless, return-less Play method is automatically recognized
 //as IAudioPlayer.Play() implementation due to matching signatures
 public void Play ()
 { /*... play a song from the CD player or something …*/ }
}
```

This is called interface **implicit implementation**, because interface members are **implicitly matched** to their interfaces by their signatures.

This looks nice and simple but has a couple of **huge shortcomings:**

First, since interface members are inherently public, **object members providing implementation must be public too**.

This is **smelly** because it leaves **public object members** openly accessible. As we strongly defined earlier, we must have no public object members **- only interface members should be accessible**. This will **prevent accidents** like letting access open into something we shouldn't.

Second, **implicit** matching does **not** allow fine **distinction** of **interface** implementations:

```
public interface IAudioPlayer
{ void Play ();  /*Play a music song*/ }

public interface IVideoGame
{ void Play (); /*Play a game*/ }

public class SmartPhone : IAudioPlayer, IVideoGame
{
 public void Play ()
 { /*...What should we do here? play a videogame or play a song? ...*/ }
}

SmartPhone phone = new SmartPhone();

//both of these will do the exact same
(phone as IAudioPlayer).Play();
(phone as IVideoGame).Play();
```

The collision in method signatures may be unfortunate. Maybe even unadvisable. But those were defined before even the notion of a smart phone would be dreamed of, and now we have to make do. **What do?**

Explicit implementation is the solution to both issues. This is done by explicitly declaring what member belongs to what interface.

```
public class SmartPhone : IAudioPlayer, IVideoGame
{
 void IAudioPlayer.Play () { /* ...play some music… */ }

 void IVideoGame.Play () { /* ...play a videogame… */ }
}

SmartPhone phone = new SmartPhone();

//now we can even use polymorphism to properly distinguish between interfaces
(phone as IAudioPlayer).Play();  //now this plays some music
(phone as IVideoGame).Play();  //but now this boots a game

phone.Play();  //COMPILER ERROR: there is no SmartPhone.Play() public member,
```
preventing ambiguous behaviour

Explicit interface definition allows fully sealing an object’s implementation by removing non-interface public members.

> IOP: Putting the LID on SOLID Programming

The five principles of **SOLID Programming** are some of the strongest foundations for a **clean** and **ever-expandable codebase**.
The **core strength** of **Interface Oriented Programming** is that it supports and **enforces SOLID** principles by design right from the analysis phase:

❖ **Single responsibility principle** [**+** strong support]
“A class should have only one reason to change”
This means any **object** should exist **only** to deal with a specific **single problem**.
IOP helps us achieve this by pushing us to **isolate** and subdivide **problems** in order to design a **clean interface tree**.

❖ **Open-closed principle** [**+** strong support]
"Software entities should be open for extension, but closed for modification"
Objects should be **extendable** by inheriting them, but **not modifiable**.
IOP rules that **no member** should be **public**, exposing **instead** properly defined **interfaces**. An **interface** can be inherited/implemented, thus it is **open** for extension, but the knowledge of an interface does not carry knowledge of its implementation, so it is invariably **closed** to modification.

❖ **Liskov substitution principle** [**++** enforced]
"S being a subtype of T, objects of type T must be replaceable with objects of type S"
This means any **child type inheriting** from another parent type, **must** satisfactorily **fulfill** every **parent public member**, and do so in a manner that fits the parents description. E.G.: If a Canine barks, a wolf and a dog must bark, too.
Since **IOP forces** you to use **interfaces** for any form of communication between objects, it becomes trivially **easy** to **swap** any **object** with any other that fulfills the **same interface.**

❖ **Interface segregation principle** [**++** enforced]
“Many client-specific interfaces are better than one general-purpose interface”
This principle is to object relationship analysis what the “Single responsibility principle” is to concrete implementation. It means that **subdividing** a **problem** (and its related interfaces) into many tiny indivisible problems is way **better than** one huge **monolithic problem**.
Proper use of **IOP requires** the application of this principle for the sake of **properly isolating problems** (and subsequently, interfaces) during the **analysis** phase.

❖ **Dependency inversion principle** [**++** enforced]
“Depend on abstractions, not concretions”
The importance of **designing** abstract logical **relationships** entirely **disregarding implementation** details is paramount for any large project. This helps avoid minor implementation problems from contaminating the analytical foundation of our codebase.
IOP enforces this by **prioritizing** the **analysis** of interface and object **relationships** completely **before** even considering any **implementation** details.

IOP enforces and supports SOLID principles guaranteeing a clean, simple and maintainable codebase.

> Recap

IOP, Interface Oriented Programming is a paradigm **focused** on using **interfaces** for the **analysis** of **object relationships.**

The **core rule** is that every **object communicates only** with **interfaces**, **never concrete types. No non-interface public members allowed.**

Subdivide problems into **as many** and **as small as possible** problems.

Generic types allow to **greatly flexibilize** the **implementation** of many **interface trees.**

> Wrap-up

Thank you very much for reading this far! I hope you enjoyed it, maybe even learnt something.
I've been experimenting with these ideas, trying to refine them, but always any constructive feedback is not only welcome but encouraged! I wanna know what you think, what edge cases might have fallen out of sight, or just general insults and well-wishing!

For comments, opinions, respectful discussions, or angry insults, reach me at my LinkedIn or my E-Mail! My full name is Héctor Colás Valtueña.

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I want to continue working, both in creating PHATASS Studios (my physics videogames studio), and continue publishing academic content such as this.

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