

- Protected constructor within a class*
- ↳ Associated with a Base class → force control on instantiation
 - ↳ Can only be accessed by
 - Derived classes
 - Class itself
 - ↳ Helps control obj creations with Singletons or Tutorial

- **Visitor**
 - Add new functionalities to objects without adding new structure
 - Useful when the object structure is stable but frequently need to change its behavior with new operators
 - Separates algorithms from the objects they operate on. Allowing you to add new operations without modifying the object structure
 - Intent to extend operations instead of types
 - Motivation
 - Both options on how to solve a relation between class and base class.... needs to choose the better approach used here
 - Do not ignore the weaknesses, and do not put yourself in an unfortunate maintenance hell.

Table 4-1. Strengths and weaknesses of different programming paradigms

Programming paradigm	Strength	Weakness
Procedural programming	Addition of operations	Addition of (polymorphic) types
Object-oriented programming	Addition of (polymorphic) types	Addition of operations

- The visitor is a OO answer for this limitation
 - Focus on allowing you to frequently add operations instead of types

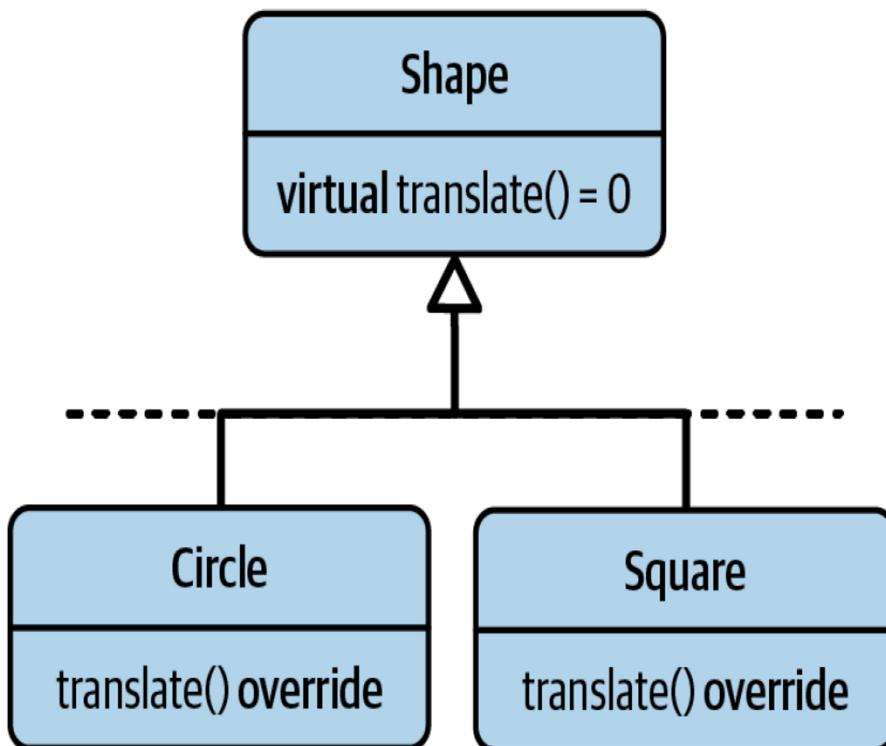
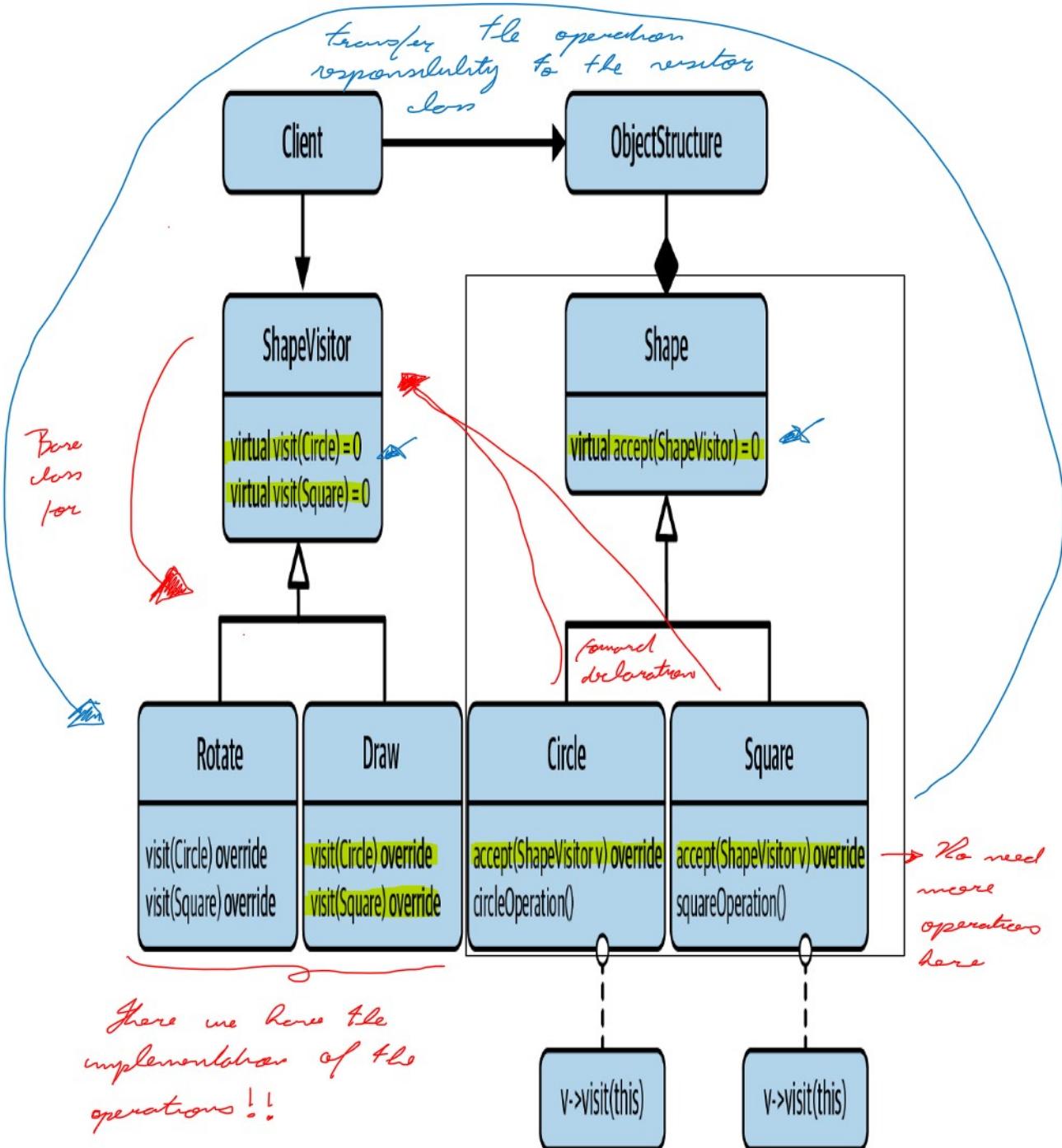


Figure 4-1. The UML representation of a shape hierarchy with two derived classes (Circle and Square)

- Once we define all types, but now we need to grow the operations on those types
 - If selected the OO approach, every new operation requires changes on the base and all derived classes (too much)
 - if used a pure virtual function
 - Using regular virtual functions, with base definitions

- Not easy to cover all the cases
- If exception, it means that the derived class must implement it too (same work)
- The visitor enables the option to add new operations easily
- Intent: Represent an operation to be performed on the elements of an object structure. Visitor lets you define a new operation without changing the classes of the elements on which it operates



- The ShapeVisitor base class represents an abstraction of shape operations
 - Comes with one pure virtual visit() function for every concrete shape in shape hierarchy
 - One for Circle
 - One for Square
 - ...
- With this class in place, it's possible to add new operations easily
 - All you need to do is to add a new derived class
 - Derived from ShapeVisitor
 - To enable Drawing shapes for example
 - Create a new Draw class, deriving from ShapeVisitor
 - Override the pure virtual function for the draw class
 - Implement the visit function in the actual .cpp file
 - Respecting the parameter type. That will allow you to define several visit functions but with different parameter types. One for each type
 - Creates several overloads to the same visit() function
- There is no need to change the Shape base class every time we need to add a new operation now

- Ok, now to use the visitor (classes derived from ShapeVisitor base class) on shapes
 - Need to add one last function
 - accept()
 - Introduced as pure virtual function in the base class
 - And has to be implemented in every derived class
 - Shape base class cannot provide a base default implementation

```

class ShapeVisitor
{
public:
    virtual ~ShapeVisitor() = default;

    virtual void visit( Circle const&, /*...*/ ) const = 0; ①
    virtual void visit( Square const&, /*...*/ ) const = 0; ②
    // Possibly more visit() functions, one for each concrete shape
};

class Draw : public ShapeVisitor
{
public:
    void visit( Circle const& c, /*...*/ ) const override;
    void visit( Square const& s, /*...*/ ) const override;
    // Possibly more visit() functions, one for each concrete shape
};

class Shape
{
public:
    virtual ~Shape() = default;
    virtual void accept( ShapeVisitor const& v ) = 0; ③
    ...
}
  
```

- Need to add one last function
 - accept()
 - Introduced as pure virtual function in the base class
 - And has to be implemented in every derived class
- Shape base class cannot provide a base default implementation
- The implementation is easy. Refers to the ShapeVisitor base visit class
 - merely needs to call the corresponding visit() function (from class Draw : public ShapeVisitor)
 - Achieved by passing the (this) pointer as an argument to visit()
 - The implementation of accept() is the same for every derive class
 - Due to a different type of the pointer, it'll trigger a different overload of the visit() function

```

{
public:
    virtual ~Shape() = default;
    virtual void accept( ShapeVisitor const& v ) = 0; ❶
    // ...
};

class Square : public Shape
{
public:
    explicit Square( double side )
        : side_( side )
    {
        /* Checking that the given side length is valid */
    }

    void accept( ShapeVisitor const& v ) override { v.visit( *this ); } ❷

    double side() const { return side_; }

private:
    double side_;
};

void drawAllShapes( std::vector<std::unique_ptr<Shape>> const& shapes )
{
    for( auto const& shape : shapes )
    {
        shape->accept( Draw{} );
    }
}

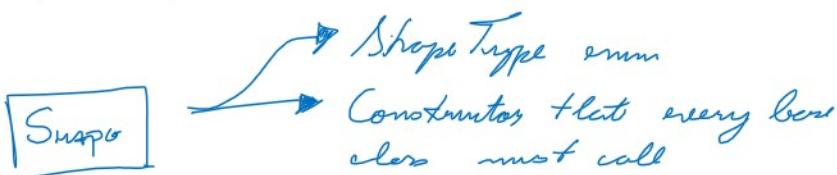
```

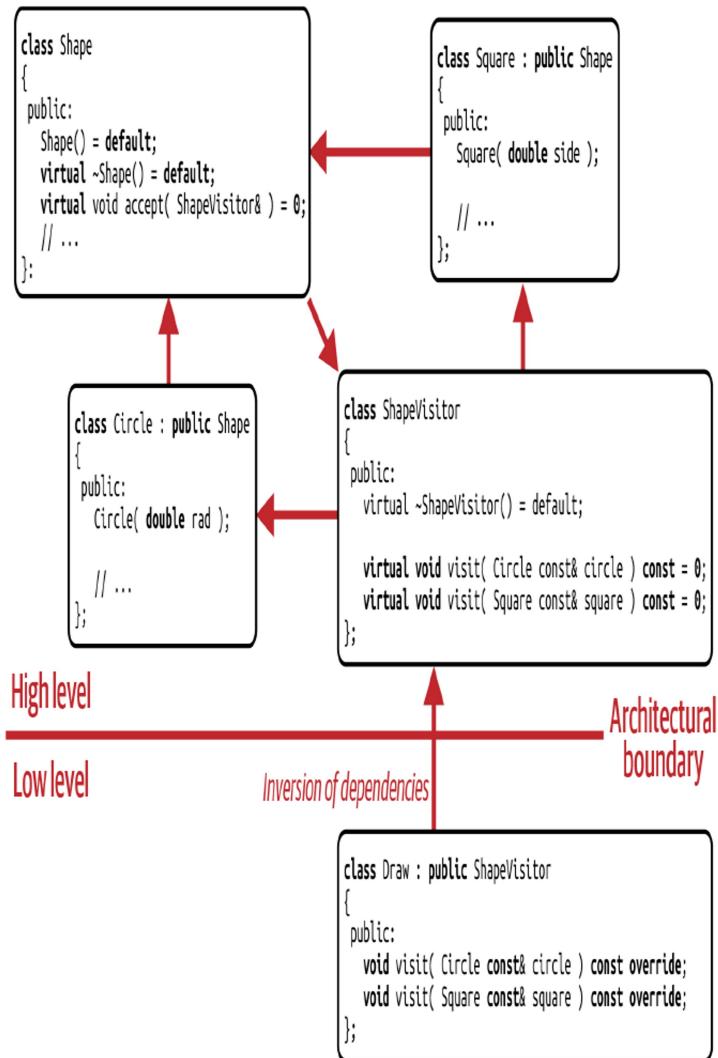
- The accept function can now be used where you need to perform an operation
 - In this case, it's calling the Draw operation (implemented in the Draw class but called visit)
 - So it call the accept method from base class shape
 - Which will trigger the corresponding derived class from shape
 - Which will trigger the associated accept method
 - ◆ Which will trigger the associated visit overload method from Draw class
 - Which is a pure virtual method overload defined in ShapeVisitor base class
- With this in place, it's now easy to add new operations to the shape hierarchy

Down sides

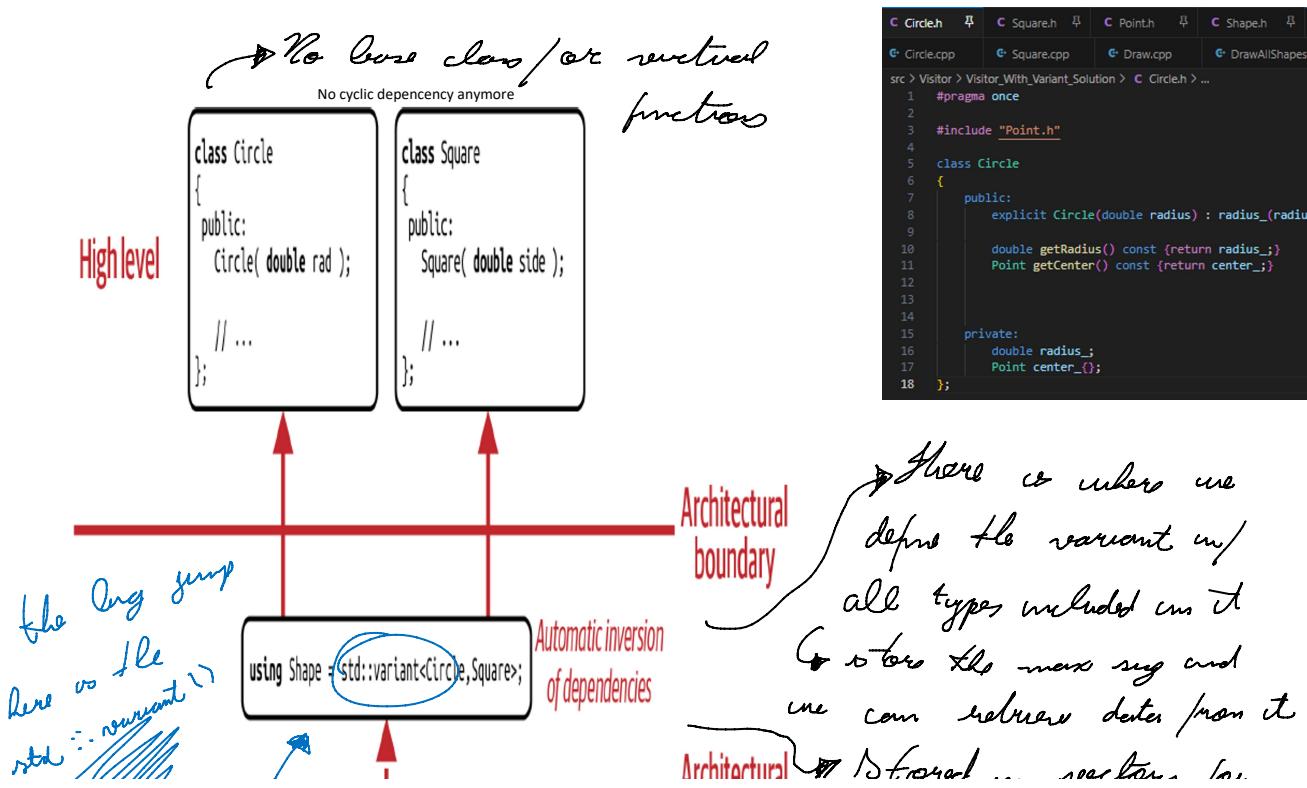
- Visitor is a work around for a OO weakness
- Low implementation flexibility
 - Needs to implement a visit() function for every concrete Shape
 - Even if the implementation is identical
 - But we can use templates....
- Return type of visitor
 - Decision is made in the visitor base class (ShapeVisitor)
 - Approach to store in the visitor and access it later
- Becomes difficult to add new types
 - Add a new shape, requires changes in all the visitor structure
 - From the base to all derived operations
 - It becomes a disadvantage
 - Visitor requires a closed set of types and provides an open set of operations
- There is a cyclic dependency among the ShapeVisitor base class, the concrete shapes and the shape base class
 - Draw -> ShapeVisitor -> Square / Circle -> Shape -> ShapeVisitor
- Intrusive nature of a visitor
 - To add a visitor needs to add a pure virtual function in the base class
 - It requires to change everybody
 - There is another nonintrusive form of the visitor design pattern
 - std::variant
- Accept() is inherited by any other layer of derived class
 - If create a new layer with Square as base class... it must implement accept as well
 - and requires to update every derived classe from the visitor base class (like adding a new type)
 - can declare the classes as final (to prevent this)
- For each operation ,we now have to call 2 virtual functions
 - accept()
 - which resolves the concrete type
 - visit()
 - which has the actual implementation
 - Should consider visitor as a slow patter now
- Cause memory fragmentation by allocating many small types in a vector
 - That is why we usually use pointers to work with the resulting shapes and visitors
 - Making it hard to perform optimizations
- hard to understand and maintain!!!!!!

Procedural solution (IMPLEMENTATION):





Guideline 17: Consider std::variant for Implementing Visitor



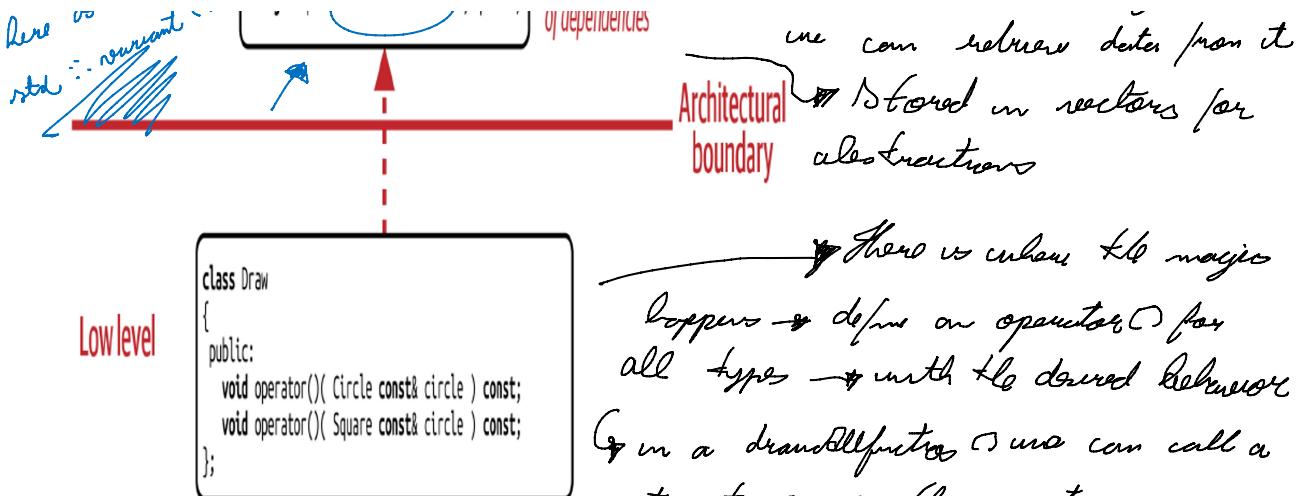


Table 4-2. Benchmark results for different Visitor implementations

Visitor implementation	GCC 11.1	Clang 11.1
Classic Visitor design pattern	1.6161 s	1.8015 s
Object-oriented solution	1.5205 s	1.1480 s
Enum solution	1.2179 s	1.1200 s
std::variant (with std::visit())	1.1992 s	1.2279 s
std::variant (with std::get_if())	1.0252 s	0.6998 s

-> The most obvious takeaway from the benchmark results is that the variant solution is far more efficient than the classic Visitor solution.

- There is where the magic happens -> defines an operator() for all types -> with the desired behavior
- in a drawAllShapes() we can call a visitor to access the operations or implement an if-else for each type with the operation

To ADD new TYPES

- First of all, you would have to update the variant itself, which might trigger a recompilation of all code using the variant type
- you would have to update all operations and add the potentially missing for the new operator() alternative(s). (The compiler will complain if one is missing)

```

Procedural Solution starting
Draw Circle
Draw Square
Draw Circle
Execution time: 0.032803 ms

OO Solution starting
Draw Circle OO
Draw Square OO
Draw Circle OO
Execution time: 0.009201 ms

OO Solution starting
Drawing a Circle
Drawing a Square
Drawing a Circle
Execution time: 0.058907 ms

Visitor with std::variant() Solution starting Using Visit
Draw Circle
Draw Circle
Draw Circle
Execution time: 0.053206 ms

Visitor with std::variant() Solution starting Using Get_if
Draw Circle
Draw Square
Draw Circle
Execution time: 0.006301 ms

```