Introduction to Intermediate Level Python

Daniel Perrefort
Center for Research Computing
University of Pittsburgh

Today's Outline

1. Writing Object Oriented Python
2. Working with "Magic Methods"

Break

3. Useful Python Design Patterns
4. Special Decorators for Classes
5. Inheritance

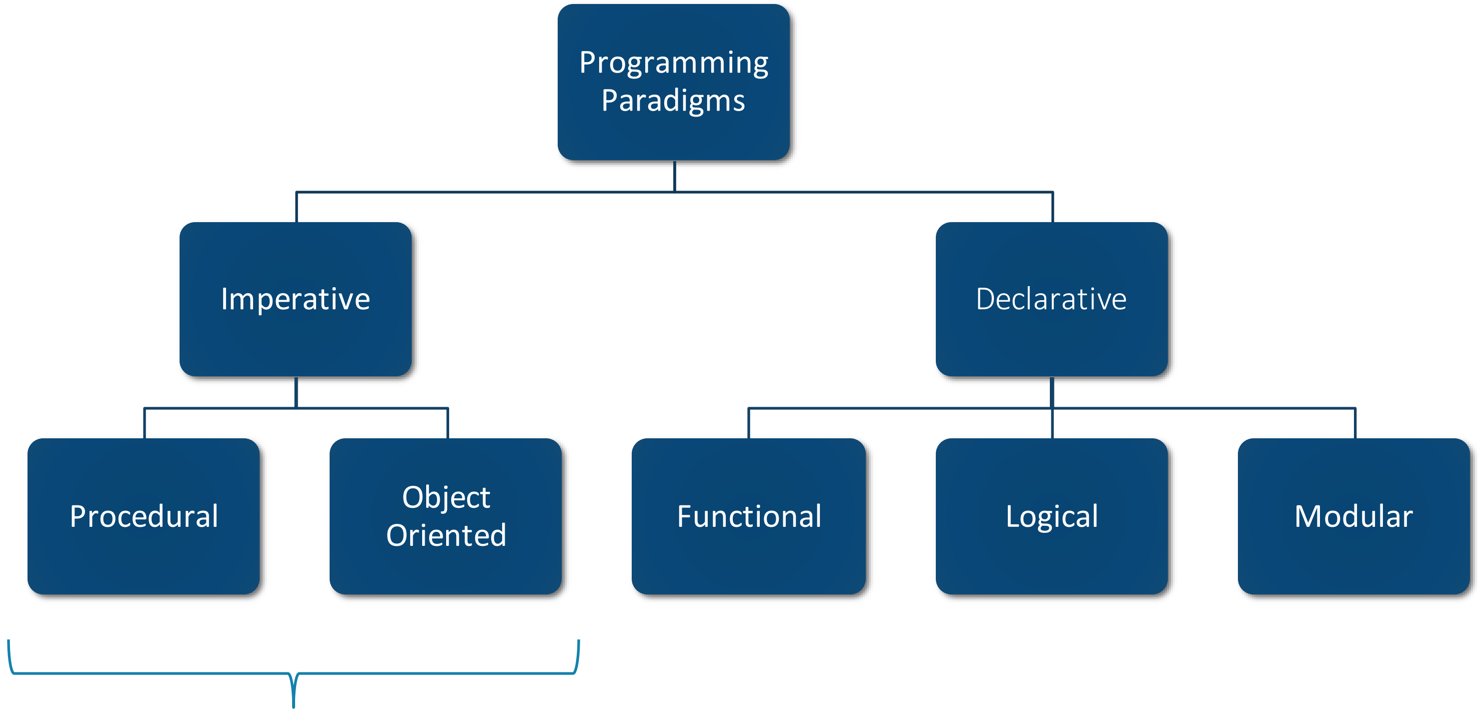
Break

6. Introduction to SOLID

Writing Object Oriented Python

What is a Programming Paradigm?

A particular style of writing software, often enforced by a programming language.



This is where we will focus today

Procedural Programming

Computational steps are divided into reusable units and the code is executed serially

```
my_list = [10, 20, 30, 40]

def sum_the_list(data):
    res = 0
    for val in data:
        res += val

    return res

print(sum_the_list(my_list))
```

Object Oriented Programming

Data and logic are combined into **objects** that reflect distinct logical constructs

```
my_list = [10, 20, 30, 40]

class ListCalculator:

    def __init__(self, data):
        self.data = data

    def sum(self):
        return sum(self.data)

instance = ListCalculator(my_list)
print(instance.sum())
```

Numpy arrays and Pandas Dataframes are examples of objects.

Everything In Python Is An Object!

(Even if you are writing "procedural" software)

Encapsulation

A big difference between procedural and OO is **encapsulation**:

"… *the bundling of data with the mechanisms or methods that operate on the data, or the limiting of direct access to some data, such as an object's components.*"

- Wikipedia

This is data:

```
prices = {
    "apples": 12.0,
    "oranges": 15.5,
    "mangos": 13.45,
    "bananas": 11.5,
}
```

This is logic:

```
def calculate_fruit_tax(price):
    """Return the tax owed on a fruit purchase"""

    return 1.02 * price
```

The *class* Keyword

The **class** acts as a template for creating new objects.

Objects are instances of the class

Objects provide access to the data/logic. Classes define what the interface looks like.

```
class Rectangle:

    def __init__(self, width, height):
        self.width = width
        self.height = height

    def area(self):
        return self.width * self.height

r1 = Rectangle(4, 5)
r2 = Rectangle(100, 100)

print(r1.area())
```

Encapsulating Data: Class Attributes

This example defines three main things:

- The *Rectangle* **class**
- The *r1* and *r2* **instances**

```
class Rectangle:
    width = 5
    height = 6

r1 = Rectangle()
r2 = Rectangle()
```

Encapsulating Data: Class Attributes

Example 1.1:

```
# Class attributes can be accessed from instances
print(r1.width)
print(r2.width)

> 5
> 5

# Class attributes can also be accessed from the class itself
print(Rectangle.width)
print(Rectangle.height)

> 5
> 6
```

```
class Rectangle:
    width = 5
    height = 6

r1 = Rectangle()
r2 = Rectangle()
```

Encapsulating Data: Class Attributes

Example 1.2:

```
print(Rectangle.width)
print(r1.width)
print(r2.width)

>
>
>

r1.width = 12
print(Rectangle.width)
print(r1.width)
print(r2.width)

>
>
>
```

```
class Rectangle:
    width = 5
    height = 6

r1 = Rectangle()
r2 = Rectangle()
```

Encapsulating Data: Class Attributes

Example 1.2:

```
print(Rectangle.width)
print(r1.width)
print(r2.width)

> 5
> 5
> 5

r1.width = 12
print(Rectangle.width)
print(r1.width)
print(r2.width)

> 5
> 12
> 5
```

```
class Rectangle:
    width = 5
    height = 6

r1 = Rectangle()
r2 = Rectangle()
```

Editing an **instance** only changes the properties of that **instance.**

Encapsulating Data: Class Attributes

Example 1.3:

```
print(Rectangle.width)
print(r1.width)
print(r2.width)
```

> 5
> 5
> 5

```
Rectangle.width = 12
print(Rectangle.width)
print(r1.width)
print(r2.width)
```

>
>
>

```
class Rectangle:
    width = 5
    height = 6

r1 = Rectangle()
r2 = Rectangle()
```

Encapsulating Data: Class Attributes

Example 1.3:

```
print(Rectangle.width)
print(r1.width)
print(r2.width)

> 5
> 5
> 5

Rectangle.width = 12
print(Rectangle.width)
print(r1.width)
print(r2.width)

> 12
> 12
> 12
```

```
class Rectangle:
    width = 5
    height = 6

r1 = Rectangle()
r2 = Rectangle()
```

Editing a **class** changes the properties of all current and future **instances.**

Encapsulating Data: Instance Attributes

The **init** method is responsible for **instantiating** the class. It is called every time a new instance is made.

The **self** variable is always the first argument in the **init** method. It represents the instance being created.

```
class Rectangle:

    def __init__(self, width, height):
        self.width = width
        self.height = height

r1 = Rectangle(4, 5)
r2 = Rectangle(100, 100)
```

Encapsulating Data: Instance Attributes

Example 2.1:

```
print(r1.width)
print(r1.height)
```

> 4
> 5

```
print(r2.width)
print(r2.height)
```

> 100
> 100

```
class Rectangle:

  def __init__(self, width, height):
    self.width = width
    self.height = height

r1 = Rectangle(4, 5)
r2 = Rectangle(100, 100)
```

Encapsulating Data: Instance Attributes

Example 2.2:

```
print(Rectangle.width)

>
```

```
class Rectangle:

    def __init__(self, width, height):
        self.width = width
        self.height = height

r1 = Rectangle(4, 5)
r2 = Rectangle(100, 100)
```

Encapsulating Data: Instance Attributes

Example 2.2:

```
print(Rectangle.width)
```

> *AttributeError: type object 'Rectangle' has no attribute 'width'*

```
class Rectangle:

    def __init__(self, width, height):
        self.width = width
        self.height = height

r1 = Rectangle(4, 5)
r2 = Rectangle(100, 100)
```

Instance attributes are not accessible from the **class**.

Class VS Instance Attributes

CLASS ATTRIBUTES

- Defined under the *class* directive
- Values are shared across all instances
- Attributes can be accessed from the class

INSTANCE ATTRIBUTES

- Defined in the __*init*__ method
- Values vary between instances
- Attributes do not exist for the class

When in doubt, you probably want an instance attribute.

Encapsulating Logic: Methods

Everything indented under the *class* keyword belongs to that class. This includes defining **methods** (i.e., functions)

The first argument is always be the instance* – traditionally called *self*.

*Technically there are exceptions to this rule. We will cover them later.

```
class Rectangle:

    def __init__(self, width, height):
        self.width = width
        self.height = height

    def area(self):
        return self.width * self.height

r1 = Rectangle(4, 5)
r2 = Rectangle(100, 100)
```

Encapsulating Logic: Methods

Example 3.1:

```
# Returned value is given as 4 * 5 = 20
print(r1.area())
> 20
```

```
class Rectangle:

    def __init__(self, width, height):
        self.width = width
        self.height = height

    def area(self):
        return self.width * self.height

r1 = Rectangle(4, 5)
r2 = Rectangle(100, 100)
```

Side Note: PEP8 Naming for Classes

- Class names are *CamalCase*
- Method and attribute names are *snake_case*
- Special cases:
  - Variables and methods starting with an underscore are "private"
  - "Dunder" methods starting and ending with double underscores extend built in functionality

```
class MyClass:

    def __init__(self):
        self._private_attr = "Don't Touch"

    def public_method(self):
        return "Hello World!"

    def _private_method(self):
        return "Not for public use"
```

- Other formatting notes:
  - One space before methods (not two)
  - Two spaces before classes

Working With "Magic Methods"

Dunder Methods

Lookups

__getattribute__
__getattr__
__delattr__
__delitem__
__delslice__
__setattr__
__setitem__
__setslice__
__missing__
__getitem__
__getslice__
__class_getitem__

equality and hashing

__eq__
__ge__
__gt__
__le__
__ne__
__lt__
__hash__

binary operators

__add__
__and__
__divmod__
__floordiv__
__lshift__
__matmul__
__mod__
__mul__
__or__
__pow__
__rshift__
__sub__
__truediv__
__xor__
__radd__
__rand__
__rdiv__
__rdivmod__
__rfloordiv__
__rlshift__
__rmatmul__
__rmod__
__rmul__
__ror__
__rpow__
__rrshift__
__rsub__
__rtruediv__
__rxor__
__iadd__
__iand__
__ifloordiv__
__ilshift__
__imatmul__
__imod__
__imul__
__ior__
__ipow__
__irshift__
__isub__
__itruediv__
__ixor__

unary operators

__abs__
__neg__
__pos__
__invert__

math

__index__
__trunc__
__floor__
__ceil__
__round__

iterator

__iter__
__len__
__reversed__
__contains__
__next__

numeric type casting

__int__
__bool__
__nonzero__
__complex__
__float__

str and repr

__str__
__repr__

context manager

__enter__
__exit__

descriptor

__get__
__set__
__delete__
__set_name__

async

__aenter__
__aexit__
__aiter__
__anext__
__await__

creation and typing

__call__
__class__
__dir__
__init__
__init_subclass__
__prepare__
__new__
__subclasses__

instance / subclass check

__instancecheck__
__subclasscheck__

modules

__import__

others

__bytes__
__fspath__
__getnewargs__
__reduce__
__reduce_ex__
__sizeof__
__length_hint__
__format__
__cmp__

Casting With __str__ (and __repr__)

Example 4:

```
r1 = Rectangle(4, 5)
print(r1)
> Square:  4 x 5
```

__str__ functions similarly to *__repr__*:

- *__str__* should be human readable
- *__repr__* provides technical information
- *__repr__* is the fallback for *__str__*

```
class Rectangle:

    def __init__(self, width, height):
        self.width = width
        self.height = height

    def __str__(self):
        return f"Square:  {self.width} x {self.height}"
```

Equality With __eq__

Example 5:

```
r1 = Rectangle(4, 5)
r2 = Rectangle(100, 100)
print(r1 == r2)
> False

r3 = Rectangle(100, 100)
print(r2 == r3)
> True

print(r2 is r3)
> False
```

```
class Rectangle:

    def __init__(self, width, height):
        self.width = width
        self.height = height

    def __eq__(self, other):
        same_width = self.width == other.width
        same_height = self.width == other.width
        return same_width and same_height
```

Each equality operator is implemented separately (*__eq__*, *__ne__*, *__gt__*, *__lt__*, *__ge__*, *__le__*)

All Binary operators have a dunder (and, or, *, /, //, @, etc.)

Indexing With __getitem__

Example 6:

```
r1 = Rectangle(4, 5)
print(r1[0])
print(r1[1])

> 4
> 5

r1[0] = 100
print(r1[0])
> TypeError: 'type' object does not support item
  assignment
```

```
class Rectangle:

    def __init__(self, width, height):
        self.width = width
        self.height = height

    def __getitem__(self, index):
        return (self.width, self.height)[index]
```

__getitem__ and *__setitem__* are also responsible for dictionary style indexing.

Callable Objects With __call__

Example 7:

```
r1 = Rectangle(4, 5)
r1(16)

> You called with object with 16
```

```
class Rectangle:

    def __init__(self, width, height):
        self.width = width
        self.height = height

    def __call__(self, value):
        print('You called this object with', value)
```

Everything in Python is an object

- Functions are callable objects
  - Functions implement the __*call*__ method

```python
class Rectangle:

    def __init__(self, width, height):
        self.width = width
        self.height = height

    def __str__(self):
        return f"Square:  {self.width} x {self.height}"

    def __eq__(self, other):
        same_width = self.width == other.width
        same_height = self.width == other.width
        return same_width and same_height

    def __getitem__(self, index):
        return (self.width, self.height)[index]

    def area(self):
        return self.width * self.height
```

Useful Python Design Patterns

Context Managers

Context managers are used to automate setup and teardown tasks for cleaner development

```python
from pathlib import Path

with Path('my_file.txt').open()  as file:
    print(file.closed)   # False

print(file.closed)   # True
```

Creating a Context Manager

Instance setup and configuration is defined in __*init*__

Make sure the file exists and open the file.

Close and delete the open file.

Add methods as necessary to make the returned object useful

```
class TemporaryFile:

    def __init__(self, path):
        self._path = Path(path)
        self._file = None

    def __enter__(self):
        self._path.touch()
        self._file = self.path.open()

    def __exit__(self, *args):
        self._file.close()
        self._path.unlink()

    def write(self, data):
        ...
```

Creating a Context Manager

Example 8:

```python
from pathlib import Path


file_path = Path('my_file.txt')
with TemporaryFile(file_path) as temp_file:
    temp_file.write('some_text')
```

```python
class TemporaryFile:
    def __init__(self, path):
        self._path = Path(path)
        self.__file = None

    def __enter__(self):
        self._path.touch()
        self._file = self._path.open()
        return self

    def __exit__(self, exc_type, exc_value, traceback):
        self._file.close()
        self._path.unlink()

    def write(self, data):
        ...
```

Context Managers – Example Use Cases

- I/O Operations
- Remote Server Connections
- Database Sessions
- User Authentication
- Data caching (with cleanup)
- Resource locking
- Hardware interactions

Generators

Example 9.1

```python
def perfect_squares(num):
    i = 0
    data = []
    while i < num:
        data.append(i  * i)
        i += 1

    return data

for value in perfect_squares(10):
    ...
```

Q: How many iterations are performed for num=100?

A: 200 iterations

Generators with Functions

Generators are built using the yield keyword

Example 9.2

```
def perfect_squares(num):
    i = 0
    data = []
    while i < num:
        data.append(i * i)
        i += 1

    return data

for value in perfect_squares(10):
    ...
```

```
def perfect_squares(num):
    i = 0
    while i < num:
        yield i * i
        i += 1

for value in perfect_squares(10):
    ...
```

Generators are memory efficient. They are also useful for reducing runtime complexity.

Generators with Classes

Iteration relies on the __*iter*__ and __*init*__ methods behind the scenes

Example 9.3

```
def perfect_squares(num):
    i = 0
    while i < num:
        yield i * i
        i += 1

    return data

for value in perfect_squares(10):
    ...
```

```
class PerfectSquares:

    def __init__(self,  num):
        self._num  = num
        self._i = None

    def __iter__(self):
        self._i = -1
        return self

    def __next__(self):
        self._i += 1
        if self._i < self._num:
            return self._i * self._I

        raise StopIteration()
```

Python provides easier ways to write generators.
Use dunders to expose more advanced behavior.

Generators with Comprehension

In practice, using comprehension is much simpler

```
my_list = [i * i  for i in range(10)]
> [1, 4, 9, 16, 25]

my_set = {i * i  for i in range(10)}
> {1, 4, 9, 16, 25}

my_dict = {i: i * i  for i in range(10)}
> {1: 1, 2: 4, 3: 9, 4: 16, 5: 25}

my_generator = (i * i  for i in range(10))
> <generator object <genexpr> at 0x7f297815f5e0>
```

Decorators

Decorators are callable objects that wrap other callable objects

The outer function accepts the unwrapped callable and returns a wrapped version

The inner function defines the new logic wrapped around the original callable

```
def outer(func):
    def inner(*args, **kwargs):
        print('I have been decorated!')
        func(*args, **kwargs)

    return inner
```

Important: Pay attention to the signature of the inner function.
That will be the new signature of the wrapped function.

Decorators

Example 10.1:

```
def my_function(x):
    print('I was given the number', x)

my_function(5)
> I was given the number 5

wrapped = outer(my_function)
wrapped(5)
> I have been decorated!
> I was given the number 5
```

```
def outer(func):
    def inner(*args, **kwargs):
        print('I have been decorated!')
        func(*args, **kwargs)

    return inner
```

The @ syntax for Decorators

Example 10.2:

```
@outer
def my_function(x)
    print('I was given the number', x)

my_function(5)
> I have been decorated!
> I was given the number 5
```

```
def outer(func):
    def inner(*args, **kwargs):
        print('I have been decorated!')
        func(*args, **kwargs)

    return inner
```

Decorators Example: @cache

```
from functools import lru_ache

@lru_cache
def return_number(x)
    print('The function was called for', x)
    return x

print(return_number(5))
> The function was called for 5
> 5

print(return_number(5))
> 5
```

Building @cache from scratch

Q: How would you build *@cache* from scratch?

```
def cache(func):
    ...
```

Building @cache from scratch

Q: How would you build *@cache* from scratch for a functions that take a single argument?

```
def cache(func):
    cached_data = dict()

    def wrapped(*args, **kwargs):
        key = str(args) + str(kwargs)
        if key not in cached:
            cached[key] = func(*args, **kwargs)

        return cached[key ]

    return wrapped
```

Down the Decorator Rabbit Hole

Three layers can be used to define decorators that take arguments.

```
def cache(max_size):

    def wrapper(func):
        cached_data = dict()

        def wrapped(*args, **kwargs):
            result = func(*args, **kwargs)
            if getsizeof(cached) + getsizeof(result) < max_size:
                ...

            return cached[arg]

        return wrapped
```

```
@cache(max_size=1000)
def return_number(x):
    ...
```

Down the Decorator Rabbit Hole

And yes... we can write it as a class

```
class Cache:

    def __init__(self, max_size):
        self._max_size = max_size

    def __call__(func):

        def wrapped(arg):
            result = func(arg)
            if getsizeof(cached) + getsizeof(result) < self._max_size:
                ...

            return cached[arg]

        return wrapped
```

```
@cache(max_size=1000)
def return_number(x):
    ...
```

Special Decorators for Classes

Built In Decorators - @property

The getter/setter pattern is commonly used to modify object state

```
car = SelfDrivingVehicle()

# Get the current value
current_speed = car.get_speed()

# Change to a new value
car.set_speed(mph=15)
```

Example 11.1

```
class SelfDrivingVehicle:

    def get_speed(self):
        """Get the current speed"""

    def set_speed(self, mph):
        """Set the current speed"""
```

Built In Decorators - @property

The property decorator turns methods into attributes

```
car = SelfDrivingVehicle()

# Get the current value
current_speed = car.speed

# Change to a new value
car.speed = 15
```

Example 11.2

```
class SelfDrivingVehicle:

    @property
    def speed(self):
        """Get the current speed"""

    @speed.setter
    def speed(self, mph):
        """Set the current speed"""
```

Built In Decorators - @property

If you don't provide a setter, an error is raised

Example 11.3

```
car = SelfDrivingVehicle()

# Get the current value
current_speed = car.speed

# Change to a new value
car.speed = 15
> AttributeError: property 'speed' of 'SelfDrivingVehicle' object
  has no setter
```

```
class SelfDrivingVehicle:

    @property
    def speed(self):
        """Get the current speed"""
```

Built In Decorators - @classmethod

Class methods can access class attributes but not instance attributes

```
class SelfDrivingVehicle:
    _top_speed = 80

    @classmethod
    def get_top_speed(cls):
        return cls._top_speed
```

Built In Decorators - @staticmethod

Static methods have no information concerning the parent class

```
class SelfDrivingVehicle:

    @staticmethod
    def print_version():
        print("Version 3.0.4")
```

Inheritance

What is Inheritance

- Inheritance allows classes to reuse logic from other classes
- Subclasses (child classes) **inherit** logic from parent classes

Single Inheritance

The **parent class** defines the basic level of behavior

The **child class** adds/overwrites functionality as necessary

The *super()* call provides access to the parent class

```
class Rectangle:

    def __init__(self, length, width):
        self.length = length
        self.width = width

    def area(self):
        return self.length * self.width


class Square(Rectangle):

    def __init__(self, length):
        super().__init__(length, length)
```

Single Inheritance

```
my_square = Square(5)
print(my_square.area())
> 25
```

```
class Rectangle:

    def __init__(self, length, width):
        self.length = length
        self.width = width

    def area(self):
        return self.length * self.width


class Square(Rectangle):

    def __init__(self, length):
        super().__init__(length, length)
```

Abstract Base Classes

Abstract classes are any class that implements abstract methods

Child classes override abstract or they are also abstract.

```
import abc

class Shape(metaclass=abc.ABCMeta):

    @abc.abstractmethod
    def area(self):
        """Return the area"""

    @abc.abstractmethod
    def perimeter(self):
        """Return the perimeter"""

class Rectangle:

    def area(self):
        print("This is overloaded")
```

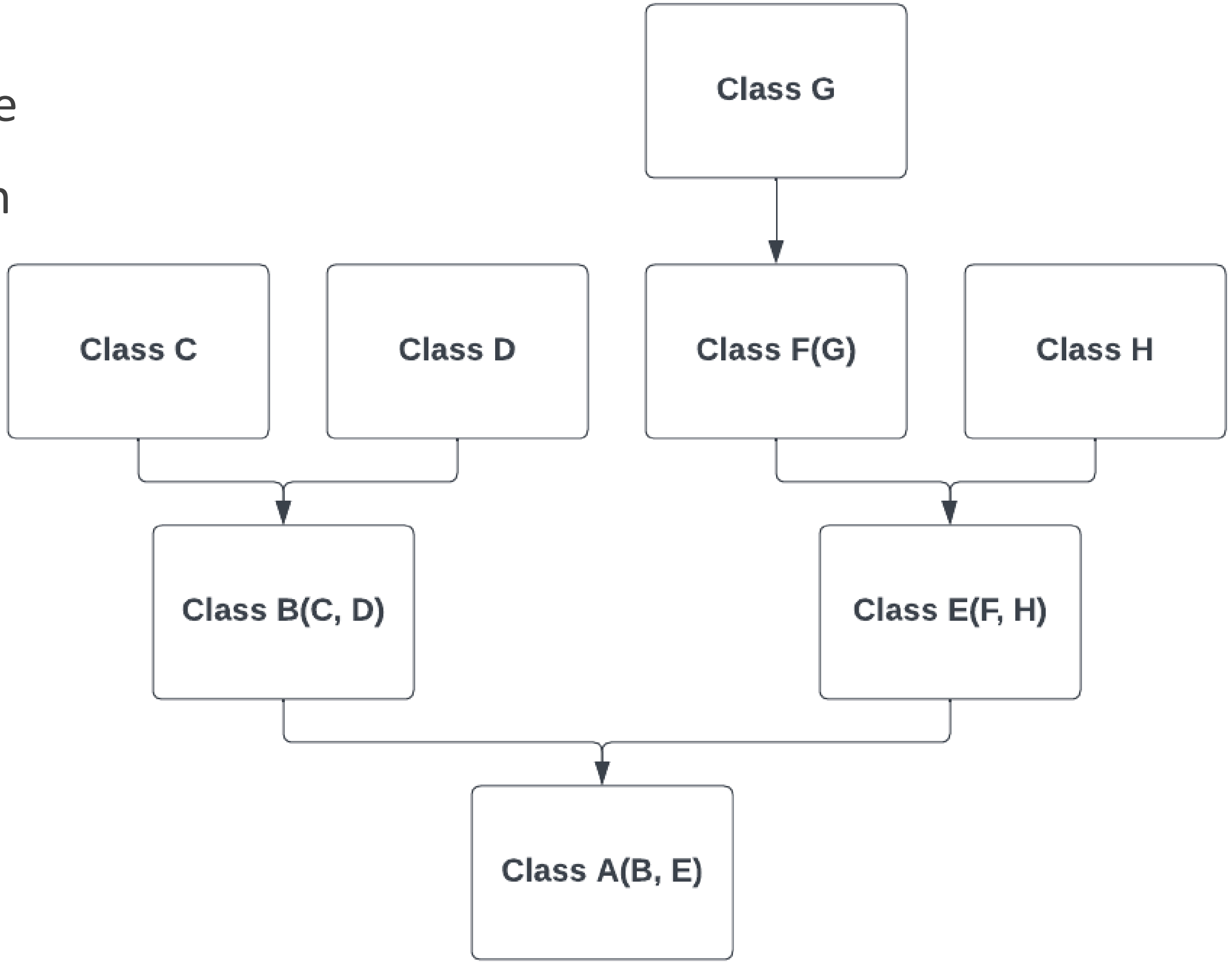
Abstract Base Classes

```
my_shape = Shape()
> Can't instantiate abstract class Shape with abstract methods
  area, perimeter

my_rectangle = Rectangle()
my_rectangle.area()
> This is overloaded
```

```
import abc

class Shape(metaclass=abc.ABCMeta):

    @abc.abstractmethod
    def area(self):
        """Return the area"""

    @abc.abstractmethod
    def perimeter(self):
        """Return the perimeter"""

class Rectangle:

    def area(self):
        print("This is overloaded")
```

Multiple Inheritance

- You can inherit from multiple classes at once
- Python will search for methods/attributes in order of inheritance
- Inheritance is mostly a depth first search. Things get complicated when classes share parents.



Break

Introduction to SOLID

SOLID Design Principles

Object Oriented software should adhere to the normal principles:

- Keep It Simple (KISS)
- Principle of Least Surprise
- You Aren’t Going To Need It (YAGNI)
- Don't Repeat Yourself (DRY)

It should also adhere to SOLID principles.

- **S** - Single-Responsibility Principle
- **O** - Open-Closed Principle
- **L** - Liskov Substitution Principle
- **I** - Interface Segregation Principle
- **D** - Dependency Inversion Principle

Single Responsibility Principle (SRP)

- Every module, class, or function should be responsible for a single functionality, and it should encapsulate that part.

- In simpler terms:
  - SRP applies at all levels of code (functions, classes, modules, packages)
  - Each "unit of code" should be responsible for a single task
  - Each unit should be properly encapsulated

- SRP **does not** argue for giant-monolithic structures. It's the opposite!

"A class should have only one reason to change"
-Robert C. Martin

SRP Example

Extract → Transform → Load

```
class Extract:

    def __init__(self):
        self._data = None

    def authenticate(self, user_key):
        """Log in to remote server"""

    def download_data(self, url):
        """Download project data"""
```

```
class Transform:

    def average_yield(data):
        """Return value metrics"""

    ... # Other calculations
```

```
class Load:

    def upload(data, DB):
        """Load data into DB"""
```

Question: Should the `authenticate` step be in its own class? Why?

Open/Closed

- Objects should be open for extension but closed for modification
  - A class should be extendable without modifying the class itself

- Open/Closed benefits from:
  - Clean inheritance structures (assuming SRP)
  - Polymorphism in dependency classes
  - Low coupling between classes

Open/Closed Example

```python
class Square:
    """Stores geometric properties for a square"""

    def __init__(self, length):
        self.length = length


class Circle:
    """Stores geometric properties for a circle"""

    def __init__(self, radius):
        self.radius = radius
```

Open/Closed Example

```
class Square:
    """Stores geometric properties for a square"""

    def __init__(self, length):
        self.length = length


class Circle:
    """Stores geometric properties for a circle"""

    def __init__(self, radius):
        self.radius = radius
```

```
class Calculator:

    def total_area(self, shape_arr):
        """Return the total area for a collection of shapes"""

        total_area = 0
        for shape in shape_arr:
            if isinstance(shape, Square):
                total_area += shape.length ** 2

            elif isinstance(shape, Circle):
                total_area += pi * shape.radius ** 2

        return total_area
```

Open/Closed Example

```
class Square:
    """Stores geometric properties for a square"""

    def __init__(self, length):
        self.length = length

    def area(self):
        return self.length ** 2

class Circle:

    def __init__(self, radius):
        self.radius = radius

    def area(self):
        return pi * self.radius ** 2
```

```
class AreaCalculator:

    def total_area(self, shape_arr):
        """Return the total area for a collection of shapes"""

        return sum(shape.area() for shape in shape_arr)
```

Notice how this solution also follows the SRP.

Liskov Substitution

Parent classes should be replaceable with their child classes

Note:

We don't actually expect random code substitutions. This is more of a "guiding principle" for designing good inheritance structures.

In practicality:

- Avoid child classes that have little in common with the parent class
- Aim for high **cohesion**

Liskov Substitution Example

You have been tasked with writing two classes - one representing a `Square` and one representing a `Rectangle`.

Define these classes in a way that:

1. One class inherits from another
2. Each class has a method for the `area` of the shape
3. The classes obey Liskov Substitution

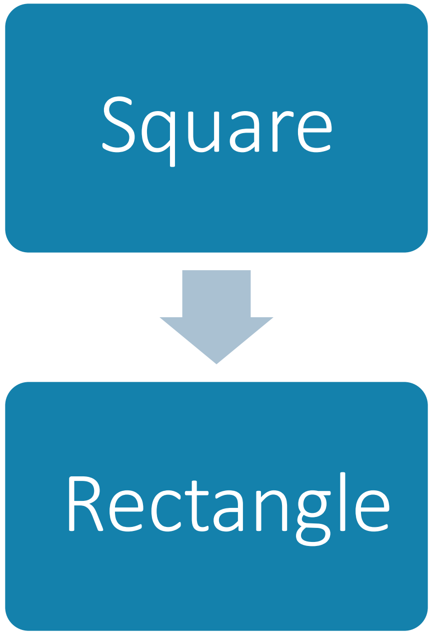
Liskov Substitution Example

You have been tasked with writing two classes - one representing a `Square` and one representing a `Rectangle`.

Define these classes in a way that:

1. One class inherits from another
2. Each class has a method for the `area` of the shape
3. The classes obey Liskov Substitution

Option 1

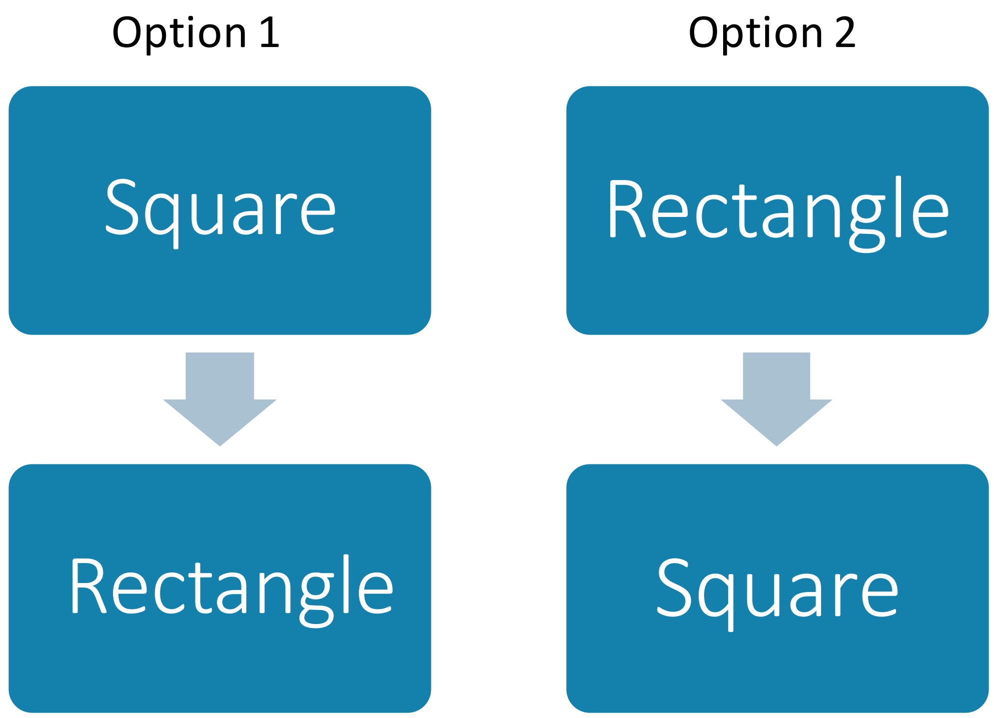


Liskov Substitution Example

You have been tasked with writing two classes - one representing a `Square` and one representing a `Rectangle`.

Define these classes in a way that:

1. One class inherits from another
2. Each class has a method for the `area` of the shape
3. The classes obey Liskov Substitution



Liskov Substitution Example

You have been tasked with writing two classes - one representing a `Square` and one representing a `Rectangle`.

Define these classes in a way that:

1. One class inherits from another
2. Each class has a method for the `area` of the shape
3. The classes obey Liskov Substitution

```python
class Rectangle:

    def __init__(self, length, width):
        self.length = length
        self.width = width

    def area(self):
        return self.length * self.width
```

Liskov Substitution Example

You have been tasked with writing two classes - one representing a `Square` and one representing a `Rectangle`.

Define these classes in a way that:

1. One class inherits from another
2. Each class has a method for the `area` of the shape
3. The classes obey Liskov Substitution

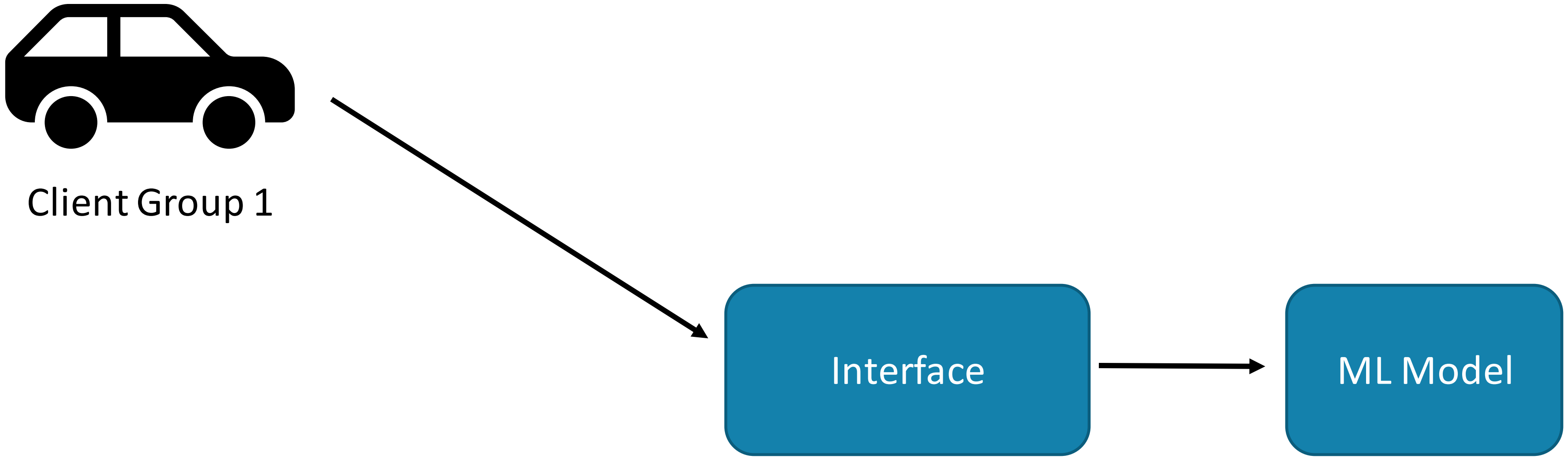
```python
class Rectangle:

    def __init__(self, length, width):
        self.length = length
        self.width = width

    def area(self):
        return self.length * self.width


class Square(Rectangle):

    def __init__(self, length):
        super().__init__(length, length)
```

Interface Segregation

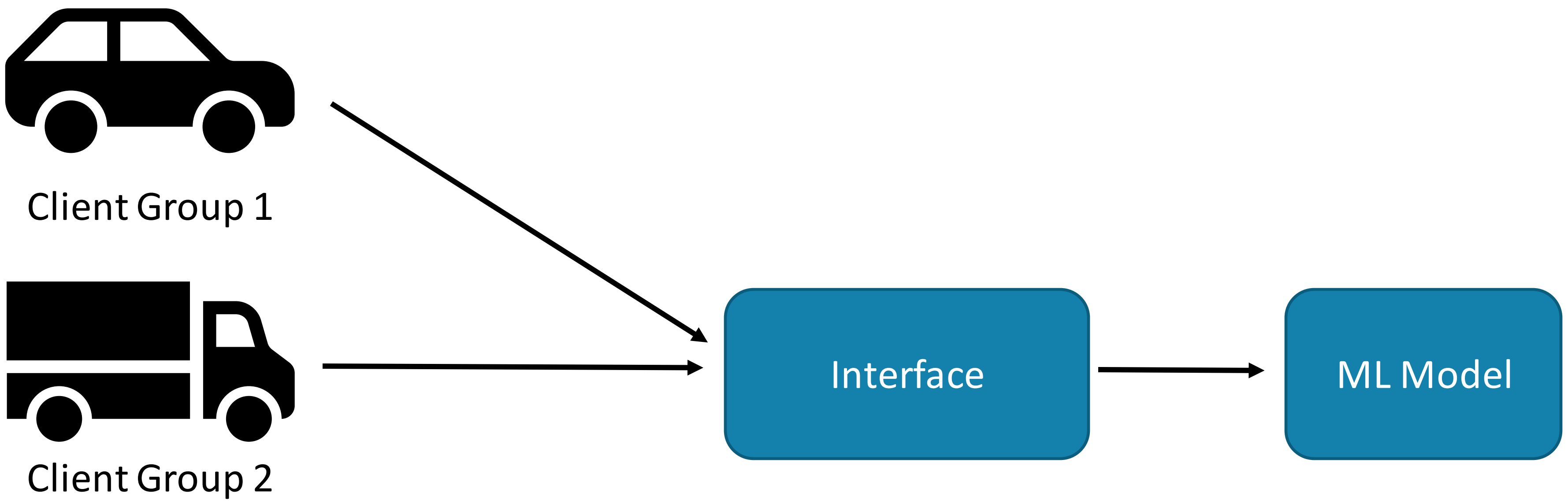
- An interface is a set of abstractions:
  - `Square.area()`
  - `Square.perimiter()`
  - `Square.width()`

- Clients should not be required to use interfaces they don’t need
  - Most applicable to large projects
  - Avoid giant, monolithic interfaces
  - Rely on smaller, client specific interfaces

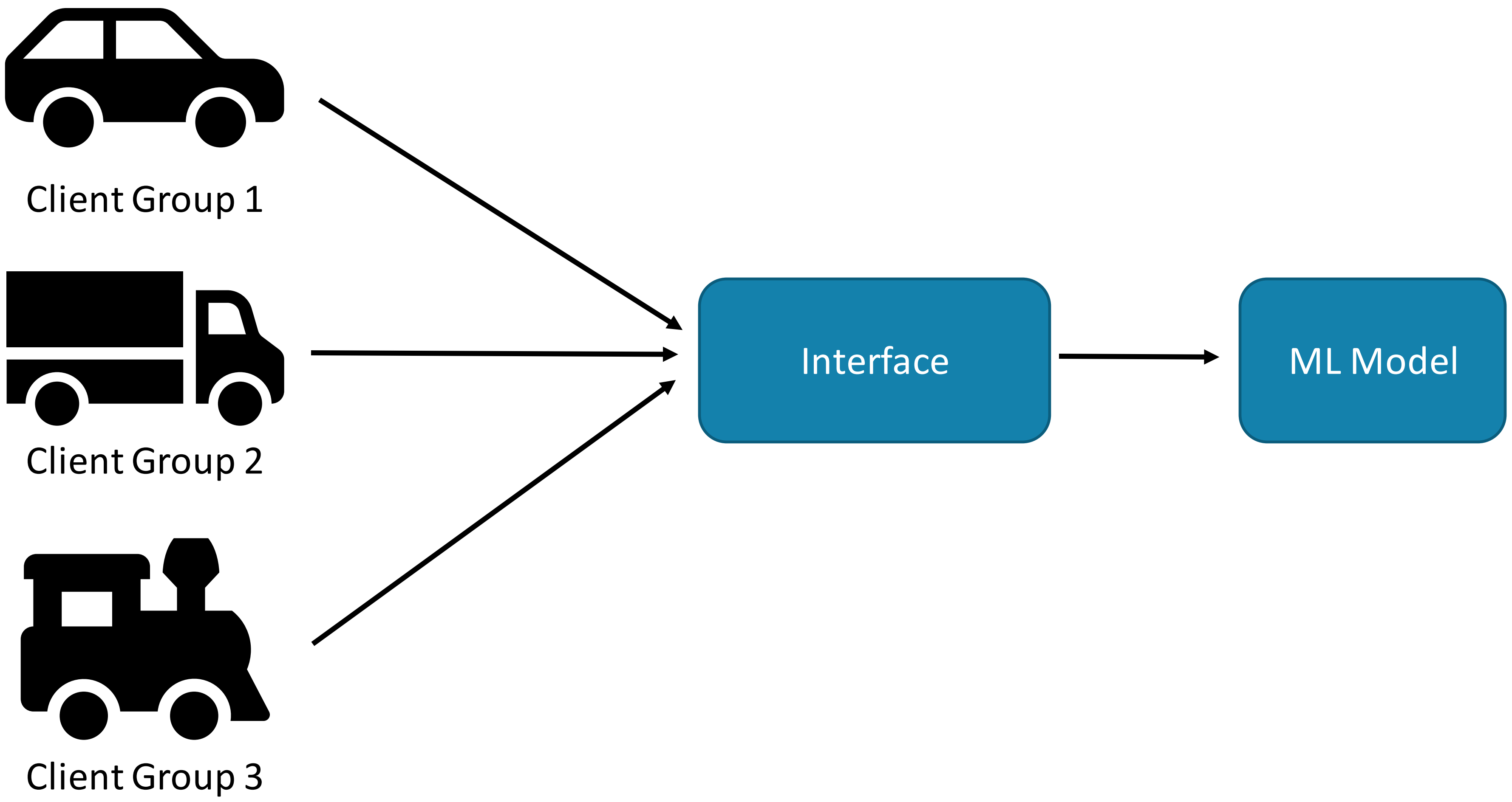
Interface Segregation Example



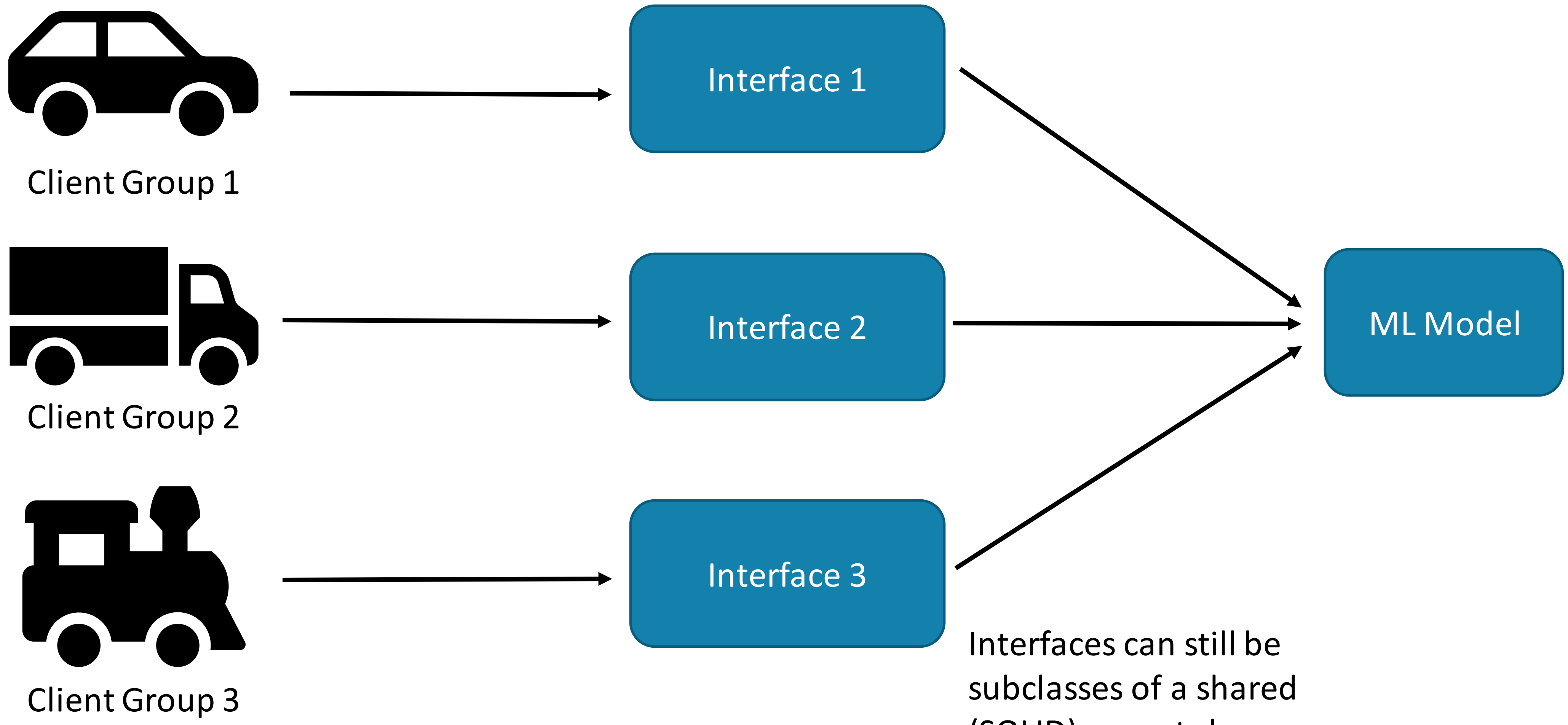
Interface Segregation Example



Interface Segregation Example



Interface Segregation Example



Interfaces can still be subclasses of a shared (SOLID) parent class

Dependency Inversion Principle

- High-level constructs should not rely on low level implementations
  - Both should depend on abstractions (e.g., interfaces).

- Abstractions should not depend on details.
  - Details (implementations) should depend on abstractions.

- In simple terms: Rely on abstractions

Dependency Inversion Example

```
class Square:
    """Stores geometric properties for a square"""

    def __init__(self, length):
        self.length = length


class Circle:
    """Stores geometric properties for a circle"""

    def __init__(self, radius):
        self.radius = radius
```

```
class AreaCalculator:

    def total_area(self, shape_arr):
        """Return the total area for a collection of shapes"""

        total_area = 0
        for shape in shape_arr:
            if isinstance(shape, Square):
                total_area += shape.length ** 2

            elif isinstance(shape, Circle):
                total_area += pi * shape.radius ** 2

        return total_area
```

Dependency Inversion Example

```
class Square:

    def __init__(self, length):
        self.length = length

    def area(self):
        return self.length ** 2

class Circle:

    def __init__(self, radius):
        self.radius = radius

    def area(self):
        return pi * self.radius ** 2
```

```
class AreaCalculator:

    def total_area(self, shape_arr):
        """Return the total area for a collection of shapes"""

        return sum(shape.area() for shape in shape_arr)
```

Notice how this solution also follows the SRP and Open/Closed.