Metaclasses

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What people say about Metaclasses

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Today we are going to look into the magic behind metaclasses and see when one would want to use them.
Before we begin talking about metaclasses, let's dive into classes.

Classes

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```
>>> class Spam:
...     pass
>>> isinstance(Spam, object)
True
>>> Spam.a = 10
>>> Spam.a
10
>>> id(Spam)
140302571738696
```

Classes are created in runtime

Example from the standard library: `collections.namedtuple`.

```
>>> from collections import namedtuple
>>> Color = namedtuple('Color', 'red green blue')
>>> c = Color(red=1, green=31, blue=57)
>>> c
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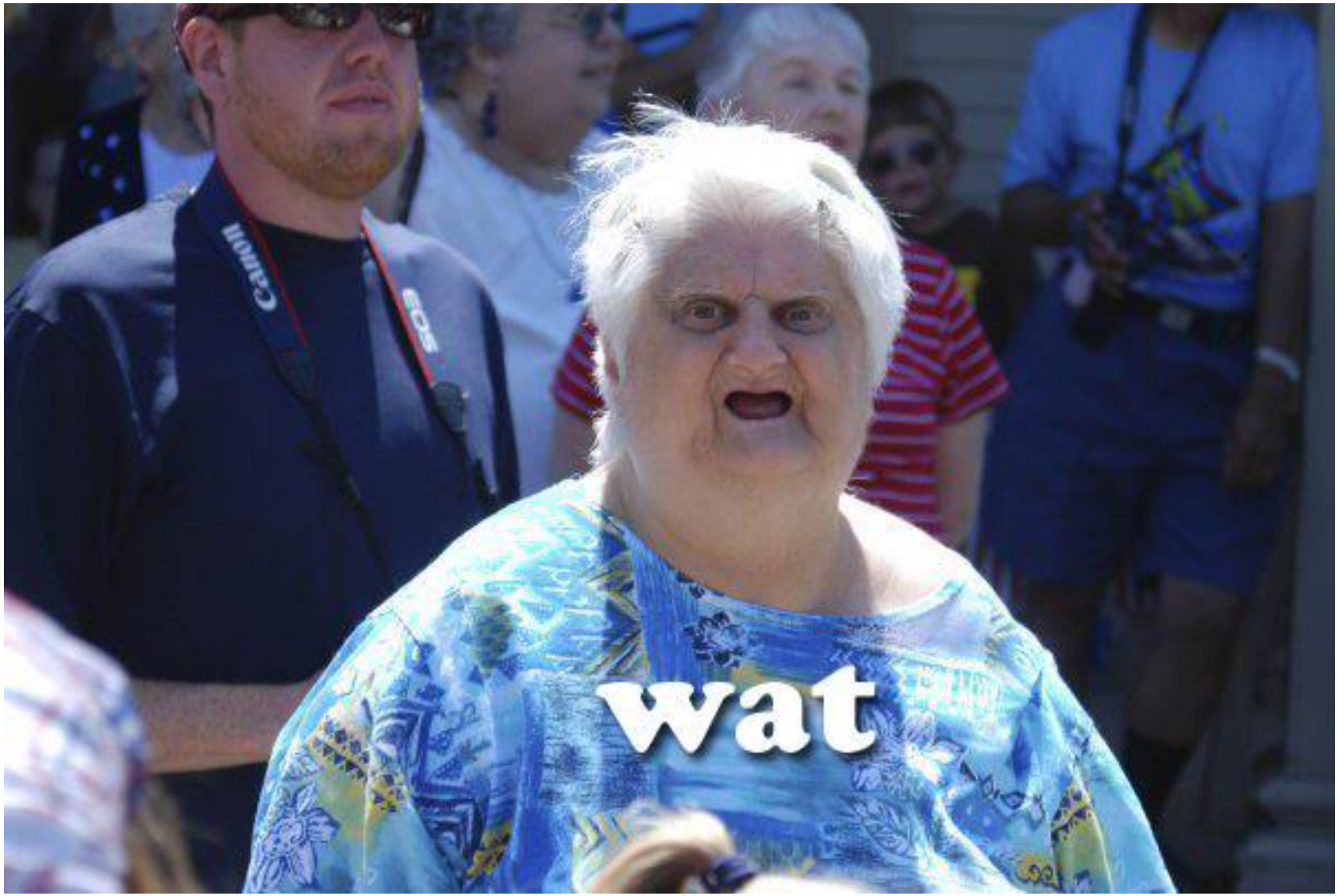
Now, what is the type of the `Color` class?

```
>>> type(Color)
<class 'type'>
```

Classes are Created in Runtime



type

There are two ways to use `type` in Python

1. `type`(object) → get the object's type
2. `type`(name of the class,
   tuple of the parent classes,
   dictionary containing attributes names and values)
   → create a new type object

Thus, the class `Color` was created using the second version of `type`.

Class Creation Process

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Consider a toy example

```
>>> class Spam(Base):
...     def __init__(self, ham):
...         self.ham = ham
...     def eggs(self):
...         return self.ham + ' and eggs'
```

Class Creation Process

Step 1: isolate the class body

```
>>> body = """
... def __init__(self, ham):
...     self.ham = ham
... def eggs(self):
...     return self.ham + ' and eggs'
... """
```

Class Creation Process

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>>> body = """
... def __init__(self, ham):
...     self.ham = ham
... def eggs(self):
...     return self.ham + ' and eggs'
... """
```

Step 2: initiate the class dictionary

```
>>> clsdict = type.__prepare__('Spam', (Base,))
```

By default `clsdict` is an empty dict.

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Step 3: execute the `body`

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>>> exec(body, globals(), clsdict)
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As a result, the `clsdict` is populated

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>>> clsdict
{'__init__': <function __init__ at 0x10ebc8158>,
 'eggs': <function eggs at 0x10ebc81e0>}
```

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>>> exec(body, globals(), clsdict)
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As a result, the `clsdict` is populated

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>>> clsdict
{'__init__': <function __init__ at 0x10ebc8158>,
 'eggs': <function eggs at 0x10ebc81e0>}
```

Step 4: Construct the class from its name, bases and the dictionary

```
>>> Spam = type('Spam', (Base,), clsdict)
>>> s = Spam('ham')
>>> s.eggs() == 'ham and eggs'
True
```

Metaclasses

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How do you use it? Like this:

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>>> class Spam(Base, metaclass=Meta):
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What does it do?

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...     def __init__(self, ham):
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```

What does it do? It replaces every usage of type in the class creation process allowing it to modify the class at the time of definition (and more)

```
>>> clsdict = Meta.__prepare__('Spam', (Base,))
>>> Spam = Meta('Spam', (Base,), clsdict)
```

__prepare__

`__prepare__` is responsible for preparing the class namespace.

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```
>>> class Meta(type):
...     @classmethod
...     def __prepare__(metaclass, name, bases, **kwargs):
...         return dict()
```

__new__ and __init__

`__new__` and `__init__` are called respectively before and after the class object is created

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```
class Meta(type):
    def __init__(cls, name, bases, clsdict, **kwargs):
        print('Meta.__init__', name, bases)
        return super().__init__(name, bases, clsdict)
    def __new__(cls, name, bases, clsdict, **kwargs):
        print('Meta.__new__', name, bases)
        return super().__new__(cls, name, bases, clsdict)
>>> class Spam(Base, metaclass=Meta):
...
Meta.__new__ Spam (<class '__main__.Base'>,)
Meta.__init__ Spam (<class '__main__.Base'>,)
```

__call__

`__call__` is called every time a new object is created

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```
>>> class Meta(type):
...     def __call__(cls, *args, **kwargs):
...         print('Meta.__call__', cls.__name__, args, kwargs)
...         return super().__call__(*args, **kwargs)
>>> class Spam(Base, metaclass=Meta):
...
>>> a = Spam('ham')
Meta.__call__ Spam ('ham',) {}
Spam.__init__
```

Examples

Check Methods Are Implemented

https://github.com/michaelarakel/pyerevan-4-mettaclasses/blob/master/examples/check_methods_exist.py

Singleton

https://github.com/michaelarakel/pyerevan-4-mettaclasses/blob/master/examples/singleton.py

Object Caching

https://github.com/michaelarakel/pyerevan-4-mettaclasses/blob/master/examples/object_caching.py

Django Pseudo-Models

https://github.com/michaelarakel/pyerevan-4-mettaclasses/blob/master/examples/pseudo_django.py

Standard Library

Metaclasses are extensively used in the standard library. For inspiration see: `abc.ABCMeta`, `enum.Enum`

And Much More

Other examples include:

1. Tracking subclasses/registering handlers
2. Ensuring attributes of a class are ordered (relevant for Python ¡ 3.7)
3. Multiple-dispatch methods
4. Making all methods of a class thread-safe
5. etc

Key Takeaways

Key Takeaways

1. Classes are objects
2. Classes are created dynamically
3. Metaclasses hook into the class creation process and modify the definition and behaviour of the classes
4. Metaclasses propagate down the inheritance hierarchy

Thank You!