

Metaclasses

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November 29, 2018

What people say about Metaclasses

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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
Color(red=1, green=31, blue=57)
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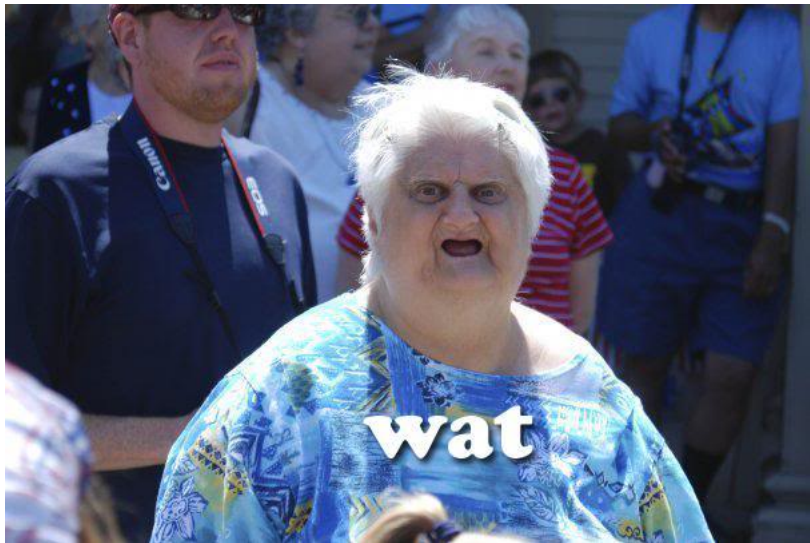
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>>> type(c)
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```

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.

Class Creation Process

Step 3: execute the body

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

```
>>> clsdict
```

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

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Step 3: execute the body

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>>> exec(body, globals(), clsdict)
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```
{'__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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>>> class Meta(type):  
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How do you use it? Like this:

```
>>> class Spam(Base, metaclass=Meta):  
...     def __init__(self, ham):  
...         self.ham = ham  
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What does it do?

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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.

__prepare__

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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-metaclasses/blob/master/examples/check_methods_exist.py

Singleton

<https://github.com/michaelarakel/pyerevan-4-metaclasses/blob/master/examples/singleton.py>

Object Caching

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

Django Pseudo-Models

https://github.com/michaelarakel/pyerevan-4-metaclasses/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:

- ➊ Tracking subclasses/registering handlers
- ➋ Ensuring attributes of a class are ordered (relevant for Python > 3.7)
- ➌ Multiple-dispatch methods
- ➍ Making all methods of a class thread-safe
- ➎ etc

And Much More...



Key Takeaways

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- 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!