Python Krus

Advanced Python

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This idiot

- Peder Bergebakken Sundt
- 24 years old
- In my fourth for a Master of Science in Computer Science
- Worked with Python for ~12 years
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This course

- This meetup will briefly touch upon many cool concepts in higher level Python programming.
- The idea is to be introduced to new concepts, not necessarily learn *everything*.
- We will mainly use vanilla Python 3 on these slides
- Many of these tricks and methods can be used in Python 2 as well
- Python 3 introduces the new print method, advanced unpacking, parameter annotations and the yield from statement among many other things.
- You're going to see the character "_" ***a lot***.
- Please don't be afraid to ask if you have any questions or didn't quite catch something.

The Interactive Interpreter

- The interactive interpreter runs Python code one line at a time.
- Any returned value is printed out, formatted using the `repr()` method
- The code on the left of this slide is how i'll display most of the examples

```
>>> i_return_a_value()
5
>>> 5
5
>>> None
>>> i_return_None()# None is the default return value
>>> 2 + 2
4
>>> "foobar"# return values are printed using repr()
'foobar'
>>> print("foobar")# print() formats using str()
foobar
```

Python is a parsed language

- Python allows dynamic behaviour making the language difficult to compile:

```
>>> print("length:", len("test"))
length: 4
>>> import builtins
>>> setattr(builtins, "len", lambda x: x.__len__() + 5)
>>> print("length:", len("test"))
length: 9
```

- We solve this by running it in an interpreter
- This is the major reason why many believe Python is slow
- This is not always the case, but many use it as a general rule of thumb

The Python parser and interpreter

The execution of Python code is divided into two steps:

1. Parse the source code and compile it into Python bytecode (usually stored in **.pyc* files or the *__pycache__/* directory)
2. Execute the simplified bytecode in an interpreter *(kinda like the Java VM but not really)*

This allows for some changes, optimizations and oddities to occur in both stages

Oddities in the Python parser

- Python allows for expressions like

```
if 5 < myFunction() <= 10:
    doSomething()
```

- In a simpler language, `5 < 6 < 7` would part-way be resolved into something like `True < 7`, which is not what we want.
- Python notices a pattern here while parsing the code, and changes the code from `5 < 6 < 7` into `5 < 6 and 6 < 7`
- We can have some fun with this

Example: Some fun with the parser

```
>>> print(5 < 7 < 10)# 5 < 7 and 7 < 10
True
>>> print(2 < 5 > 2)# 2 < 5 and 5 > 2
True
>>> print("a" in "aa" in "aaa")# "a" in "aa" and "aa" in "aaa"
True
>>> print(not 7 == True is not False)# not 7 == True and True is not False
True
```

Variable function arguments

- A Python method can take in a unknown amount of arguments
- These come in the form of lists and dictionaries
- * denotes a list of positional arguments
- ** denotes a list of keyword arguments

```
>>> def myfunc(*args, **kwargs):
...     print(args)
...     print(kwargs)
>>> myfunc(1, 2, 3, 4, foo="bar", five=5)
(1, 2, 3, 4)
{'foo': 'bar', 'five': 5}
```

Advanced (iterator) unpacking

- Python 2 had iterator unpacking:

```
>>> a, b, c = range(3)
>>> (a, c)
(0, 2)
```

- Python 3 introduces advanced unpacking using similar syntax to *args:

```
>>> a, *rest, b = range(10)
>>> (a, rest, b)
(0, [1, 2, 3, 4, 5, 6, 7, 8], 9)
```

Polymorphism in Python

- Everything in Python is an object *(or at least a psuedo object, which is the case for al the primitive types)*
  - Functions and classes are objects
  - Even True and False are objects
  - Even the code itself is an object!
- Python 1 introduced function names like __init__() and __str__() to give the different types a common interface:

  `5 == 6` is interpreted and executed as

  `(5).__eq__(6)` by the python parser (without the needed name lookups for native types)
- Python uses these methods behind the scenes when running code
- We can overload/replace these!

How to view the contents of an object

```
>>> dir(5) # Lets look at the attributes the object 5 contains
['__abs__', '__add__', '__and__', '__bool__', '__ceil__', '__class__', '__delattr__',
'__dir__', '__divmod__', '__doc__', '__eq__', '__float__', '__floor__', '__floordiv__',
'__format__', '__ge__', '__getattribute__', '__getnewargs__', '__gt__', '__hash__',
'__index__', '__init__', '__init_subclass__', '__int__', '__invert__', '__le__',
'__lshift__', '__lt__', '__mod__', '__mul__', '__ne__', '__neg__', '__new__', '__or__',
'__pos__', '__pow__', '__radd__', '__rand__', '__rdivmod__', '__reduce__', '__reduce_ex__',
'__repr__', '__rfloordiv__', '__rlshift__', '__rmod__', '__rmul__', '__ror__', '__round__',
'__rpow__', '__rrshift__', '__rshift__', '__rsub__', '__rtruediv__', '__rxor__',
'__setattr__', '__sizeof__', '__str__', '__sub__', '__subclasshook__', '__truediv__',
'__trunc__', '__xor__', 'bit_length', 'conjugate', 'denominator', 'from_bytes', 'imag',
'numerator', 'real', 'to_bytes']
```

Type and attribute methods

- Python 1 defined a common interface for builtin objects to implement. This has since been built and extended upon since.
- This convention is what allows us to make our objects able to cooperate as well as they do today!
- `if [1, 2]: print("The list has members")`

  is interpreted as

  `if [1, 2].__bool__(): print("The list has members")`

  E.G: ow the object implement `.__bool__()` defines the "*truthiness*" of the object.

```
myobject.__int__()  == int (myobject)
myobject.__str__()  == str (myobject)
myobject.__repr__() == repr(myobject)
myobject.__bool__() == bool(myobject)
myobject.__len__()  == len (myobject)
myobject.__list__() == list(myobject)
myobject.__iter__() == iter(myobject)
```

Comparison operators

- When you compare two objects, Python needs to know how to compare them.
- A least one of the two objects must implement a comparison method for this to work. This is a method which usually returns either True or False
- `["a", "b"] > None`

  is interpreted as

  `["a", "b"].__gt__(None)`

  it is up to the objects to define the operator behaviour

```
myobject.__lt__(self, other) # Less than
myobject.__le__(self, other) # Less than or equal
myobject.__eq__(self, other) # Equals
myobject.__ne__(self, other) # Not Equal
myobject.__gt__(self, other) # Greater than
myobject.__ge__(self, other) # Greater than or equal
```

Arithmetic operators

- Behaves the same way as comparison operators, except they're not expected to return a boolean
- Right hand side counterparts exists as well
- Operator precedence is handled by the parser and can not be overridden

(as far as i know)

```
object.__add__     (self, other)  ==  self +  other
object.__sub__     (self, other)  ==  self -  other
object.__mul__     (self, other)  ==  self *  other
object.__matmul__  (self, other)  ==  self @  other
object.__truediv__ (self, other)  ==  self /  other
object.__floordiv__(self, other)  ==  self // other
object.__mod__     (self, other)  ==  self %  other
object.__pow__     (self, other)  ==  self ** other
object.__lshift__  (self, other)  ==  self << other
object.__rshift__  (self, other)  ==  self >> other
object.__and__     (self, other)  ==  self &  other
object.__xor__     (self, other)  ==  self ^  other
object.__or__      (self, other)  ==  self |  other
```

Container methods

- Lists, dictionaries, sets, tuples, deques and strings all use the same container interface methods:
- ```
  a = myobject[5]
  myobject["foo"] = "bar"
  del myobject[5]
  ```

  is interpreted as

  ```
  a = myobject.__getitem__(5)
  myobject.__setitem__("foo", "bar")
  myobject.__delitem__(5)
  ```

- Slicing was hacked in as an afterthought:

```
>>> class MyClass:
...   def __getitem__(self, value):
...     print(value)
>>> myobject = MyClass()
>>> myobject[3]
3
>>> myobject[3:4]
slice(3, 4, None)
```
```

Attribute handlers

- All objects must have an implementation of __getattr__, __setattr__ and __delattr__
- Luckily you inherit a very good implementation by default!
- Used whenever you access a member attribute of an object:

```
print(myobject.foo)
```

is executed as

```
print(myobject.__getattr__("foo"))
```

- Similar interface to containers, but must be implemented on all objects

```
>>> class AttributeDict(dict):
...     __getattr__ = dict.__getitem__
...     __setattr__ = dict.__setitem__
...     __delattr__ = dict.__delitem__
>>> mydict = AttributeDict()
>>> mydict["foo"] = 5
>>> print(mydict.foo)
5
```

New style classes and objects

- The concept of a descriptor was introduced late in Python 2.
- In general, a descriptor is an object attribute whose access has been overridden by methods.
- A descriptor is an object with `__get__()`, `__set__()`, and `__delete__()` methods.
- You can easily make these using `property()`

- In Python 2 you had to inherit "object" to get the descriptor logic, while this behaviour default in Python 3.
- Object adds the `__getattribute__`, `__setattribute__` and `__delattribute__` member functions which handle descriptor logic before calling `__getattr__`, `__setattr__` and `__delattr__` respectively.

Properties - a use of descriptors

```
>>> class MyClass:
...     def foo():
...         doc = "The foo property."
...         def fget(self):
...             return "The value of foo"
...         def fset(self, value):
...             print("foo was set to", value)
...         def fdel(self):
...             pass
...         return locals()
...     foo = property(**foo())
```

```
>>> myobject = MyClass()
>>> myobject.foo = 5
foo was set to 5
>>> print(myobject.foo)
The value of foo
>>> print(MyClass.foo.__doc__)
The foo property.
```

Properties simplified

```
>>> class MyClass:
...     @property
...     def foo(self):
...         return input("What is foo? ")
...     @foo.setter
...     def foo(self, value):
...         print("Foo was set to", value)
...
```

```
>>> myobject = MyClass()
>>> print(myobject.foo)
What is foo? Hello
Hello
>>> print(myobject.foo)
What is foo? World
World
>>> myobject.foo = 5
Foo was set to 5
```

Callables

- An object is a "*callable*" object if it implements the __call__ method

  ```
  myobject(1, 2)
  ```
  is executed as
  ```
  myobject.__call__(1, 2)
  ```

- `def` does this for you:

  ```
  >>> def myfunc(): pass
  >>> myfunc.__call__
  <method-wrapper '__call__' of function object at 0x000000E4B2703E18>
  ```

Callable example

```
>>> class Funky:
...     def __call__(self):
...         print("Look at me, I'm acting like a function!")
>>> f = Funky() # creating an instance of this class
>>> f() # Then we try to call this object
Look at me, I'm acting like a function!
```

Lambda functions *(inline/anonymous functions)*

- Callables are simply objects
- Because of this we can pass a callable in as an argument to a function
- The lambda statement simplifies this, allowing you to define callables inline:

```
>>> def double(value):
...     return value + value
>>> def call(func):
...     print('func("test") returns:', func("test"))
>>> call(double)
func("test") returns: testtest
>>> call(lambda x: x + x + x)
func("test") returns: testtesttest
>>> call(lambda x: 5)
func("test") returns: 5
```

Class descriptions

- When you define a class in Python, you’re in reality storing a callable object, which produces instances of the class you described:
- `MyClass.__call__(*args, **kwargs)`

  is a method which does: *(somewhat simplified)*

```
instance = MyClass.__new__(MyClass, *args, **kwargs)# The instance is constructed by __new__
instance.__init__(*args, **kwargs)# The newly constructed instance is initialized by __init__
return instance
```

Default __new__ constructor simplified

```
class MyClass:
    def __new__(cls, *args, **kwargs):
        self = object() # start an empty object
        for attribute_name in dir(cls):
            attribute_value = getattr(cls, attribute)
            if type(attribute_value) is function:
                def instance_method(*args, **kwargs):
                    return attribute_value(self, *args, **kwargs)
                setattr(self, instance_method) # this is where 'self' is provided in methods
            else:
                setattr(self, attribute_value)
        return self
```

(This implementation of __new__ doesn't account for everything, but the understanding here is key)

Annotations

- A new feature introduced in Python 3.0, which has not been backported
- Used to annotate what types a function uses and returns

```
>>> def myfunc(a: int, b: str) -> list:
...     assert type(a) is int
...     assert type(b) is str
...     #do something
>>> myfunc.__annotations__
{'a': <class 'int'>, 'b': <class 'str'>, 'return': <class 'list'>}
```

- Python does not enforce these in any way, mainly used for documentation and better assistance from IDEs and linters

Decorators

- Functions are just callable objects
- We can make changes to these callable objects
- This we call “decorating” a function
- A “decorator” is simply a function that takes in a callable object as a parameter and returns the decorated version of that callable object:

```
myfunc = mydecorator(myfunc)
```

Decorator syntax

- Python added syntactical sugar to make this more practical:

```
def myfunc(): pass
myfunc = mydecorator(myfunc)
```

can be written as

```
@mydecorator
def myfunc(): pass
```

- You can stack multiple decorators on a single function

Decorator example: HTML tag

```
>>> def with_b_tag(func):# a decorator
...     def new_func(*args, **kwargs):
...         return "<b>" + func(*args, **kwargs) + "</b>"
...     return new_func
...
>>> @with_b_tag
... def hello_world():
...     return "Hello, World!"
...
>>> print(hello_world())
<b>Hello, World!</b>
```

Decorator example: memoizer

```
>>> def memoize(func):# a decorator
...     memory = {}
...     def new_func(argument):
...         if argument in memory:
...             return memory[argument]
...         else:
...             value = func(argument)
...             memory[argument] = value
...             return value
...     return new_func
...
```

```
>>> @memoize
... def fibonacci(n):
...     if 0 <= n <= 1:
...         return n
...     return fibonacci(n-1) + fibonacci(n-2)
...
>>> print(fibonacci(200))
280571172992510140037611932413038677189525
```

- This saves a lot of runtime

Decorator example: logging

```
>>> def log(func):# a decorator
...     def new_func(*args):
...         print(func.__name__ + str(args))
...         ret = func(*args)
...         print(func.__name__, "returned:", ret)
...         return ret
...     return new_func
...
>>> @log
... def foo(value):
...     return value.upper() + value.lower()
...
```

```
>>> @log
... def bar(value1, value2):
...     return foo(value1)[::-1] + foo(value2)
...
>>> print("final result:", bar("Hello", "World"))
bar('Hello', 'World')
foo('Hello',)
foo returned: HELLOhello
foo('World',)
foo returned: WORLDworld
bar returned: ollehOLLEHWORLDworld
final result: ollehOLLEHWORLDworld
```

Decorators with parameters

- Decorators alone might seem a bit limiting
- Making a decorator for every single edge case is a lot of work
- We can solve this by “cheating” a little
- We can make a function which returns the decorator we want
    - In this course we’ll call them “decorator builders”, but they’re often just called decorators
- This function will be able to take in other parameters as well!

Decorator builder example: Generic HTML tag

```
>>> def with_tag(tag):# a decorator builder
...     def decorator(func):# a decorator
...         def new_func(*args, **kwargs):
...             return "<" + tag + ">" + func(*args, **kwargs) + "</" + tag + ">"
...         return new_func
...     return decorator
...
>>> @with_tag("b")
... @with_tag("i")
... def welcome(name):
...     return "Hello, " + name.split()[0] + "!"
...
>>> print(welcome(input("Enter your name: ")))
Enter your name: Peder B. Sundt
<b><i>Hello, Peder!</i></b>
```

Decorator example: Register

```
>>> functions = {}
>>> def register(func):
...     functions[func.__name__] = func
...     return func
...
>>> @register
... def foo(a, b):
...     return a + b
...
>>> foo(1, 2)
3
>>> functions["foo"](1, 2)
3
```

Decorator builder example: with_resource

```
def with_resource(filename):# a decorator builder
    with open(filename, "r") as f:
        file = f.read()

    def decorator(func):# a decorator
        def new_func(*args, **kwargs):
            return func(*args, file, **kwargs)
        return new_func
    return decorator

from flask import Flask# a popular library for web development
import time
app = Flask("My server name")

@app.route("/index.html")
@with_resource("resources/frontpage_template.html")
def frontpage_get(request, template):
    date = time.strftime("%B %d, %Y")
    return template.format({"date": date})
```

Context Managers

```
>>> with open("my_file.txt", "r") as f:
...     data = f.read()
>>> print(data)
I'm awesome!
```

- The `with` statement uses what we call a context manager
- Context managers are simply an object which implements the `__enter__` and `__exit__` methods.
- `__enter__` is called at the start of the `with` block, optionally storing the returned value `as f`.
- `__exit__` is called when exiting the `with` block
- `open()` uses its `__exit__` method to close the file.

Context Manager example: HTML Tag

```
>>> class Tag:
...     def __init__(self, tag):
...         self.tag = tag
...     def __enter__(self):
...         print("<" + self.tag + ">")
...     def __exit__(self, type, value, traceback):
...         print("</" + self.tag + ">")
...
>>> with Tag("b"):
...     print("This text is bold!")
<b>
This text is bold!
</b>
```

Context Manager example: Switch Case *(don't actually do this in production)*

```
>>> class switch():
...     def __init__(self, key):
...         self.key = key
...     def __enter__(self):
...         return self.case
...     def __exit__(self, *args):
...         pass
...     def case(self, key):
...         def decorator(func):
...             if self.key == key:
...                 func()
...             return func
...         return decorator
...
```

```
>>> for key in (4, 5, 6):
...     print("key is", key)
...     with switch(key) as case:# the switch
...         @case(4)
...         def unimportant_name():
...             print("foo")
...         @case(5)
...         @case(6)
...         def unimportant_name():
...             print("bar")
...
key is 4
foo
key is 5
bar
key is 6
bar
```

Metaclasses

- Metaclasses can be a controversial topic
- Some believe it overcomplicates the object model
- Whether you want to use them or not is up to you
- They present lots of interesting opportunities for reducing boilerplate and make nicer APIs

What is a Metaclass?

```
>>> class MyClass: pass
>>> type(MyClass)
<class 'type'>
>>> myobject = MyClass()
>>> type(myobject)
<class '__main__.MyClass'>
>>> isinstance(myobject, MyClass)
True
>>> isinstance(MyClass, type)
True
```

- A metaclass is the parent of a class object
- All classes inherit the metaclass `type` by default
- We can therefore make classes using `type` instead of using the `class` statement:

```
>>> MyClass = type('MyClass', (), {})
>>> MyClass
<class '__main__.MyClass'>
```

Using type instead of the class statement

- These two code snippets are (almost) identical:

```
>>> class Foo:
...     x = 5
>>> class Bar(Foo):
...     def get_x(self):
...         return self.x
>>> mybar = Bar()
>>> mybar.get_x()
5
```

```
>>> Foo = type('Foo', (), dict(x=5))

>>> Bar = type('Bar', (Foo,), dict(get_x = lambda self: self.x))


>>> mybar = Bar()
>>> mybar.get_x()
5
```

Metaclasses are callable

- We can use `type` as a function to make new classes
- The `class` statement does the same thing
- This means the `class` statement should accept *any* callable as its metaclass

```
>>> class MyClass(metaclass = print):
...     pass
MyClass () {'__module__': '__main__', '__qualname__': 'MyClass'}
>>> print(MyClass)
None
```

Making your own metaclasses

- Making your own metaclass is as simple as inheriting `type`:
- Using it is as simple as setting `metaclass = MyMetaClass` in the parent list

```
>>> class MyMeta(type):
...     pass
>>> class MyClass1(metaclass = MyMeta):
...     pass
>>> type(MyClass1)
<class '__main__.MyMeta'>
>>> MyMeta("MyClass2", (), {})
<class '__main__.MyClass2'>
```

Example metaclass usage: SQLAlchemy *(peewee does the same)*

```
from sqlalchemy.ext.declarative import declarative_base
from sqlalchemy import Column, Integer, String
import conf

engine = create_engine(conf.db_url)
Base = declarative_base()
Session = sessionmaker(bind=engine)

class User(Base):
    __tablename__ = 'users'

    name = Column(String(10), primary_key=True)
    card = Column(String(20))
    rfid = Column(String(20))
    credit = Column(Integer)

    name_re = r"[a-z]+"
    card_re = r"(([Nn][Tt][Nn][Uu])?[0-9]+)?"
    rfid_re = r"[0-9a-fA-F]*"

session=Session()
# Let's find all users with a negative credit
slabbedasker=session.query(User).filter(User.credit<0).all()
for slubbert in slabbedasker:
        print(slubbert.name, "-", slubbert.credit)
```

Iterables

- An iterable object is in Python defined as “An object capable of returning its members one at a time.”
- Most of Python considers an object to be iterable if it implements `__iter__`
- Lists, sets, dictionaries, deques, strings and bytearrays among many other implements this interface.
- `__iter__` is a method that returns an Iterator-like object
- The built in function `iter(myobject)` simply returns `myobject.__iter__()`

Iterators

```
>>> myiter = iter([1, 2, 3])
>>> myiter
<listiterator object at 0x7f855c944400>
>>> myiter.next()
1
>>> myiter.next()
2
>>> myiter.next()
3
>>> myiter.next()
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
StopIteration
```

- when we call `myiter.next()` the last time, `StopIteration` is raised instead.
- This is how an iterator signals their end
- This means iterators can have an unknown length

Iterators

- `for` loops will exhaust iterators for you:

```
>>> for i in iter([1, 2, 3]): print(i, end=" ")
1 2 3
```

- `for` loops also call `iter()` for you

```
>>> class MyClass:
...     def __iter__(self): pass
...
>>> for i in MyClass(): print(i)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: iter() returned non-iterator of type 'NoneType'
```

Generators

- A Generator is a kind of an iterator which generates its values on-the-fly as you need them

- This is achieved by making `iter(mygenerator()).next()` compute the next value when it is being called

- This can save a lot of memory and result in some nifty speedups across the line

- Python 3 changed the `range` method from producing a `list` to producing a generator type:

- Python 2:

```
>>> range(5)
[0, 1, 2, 3, 4]
```

- Python 3:

```
>>> range(5)
range(0, 5)
>>> list(range(5))
[0, 1, 2, 3, 4]
```

The yield statement

- `yield` allows you to make generators with ease
- The `yield` statement resembles `return` in many ways
- When `yield` is called, the value is outputted and the function is halted until next value is requested.
- `return` in a generator will raise a `StopIteration` exception

```
>>> def mygenerator():
...     yield 1
...     print("Hello, World!")
...     yield 2
...     return 3
...
>>> for i in mygenerator(): print(i)
...
1
Hello, World!
2
```

The yield from statement

- The `yield from` was introduced in Python 3.4
- `yield from` is used when you want to pass along the result from an another generator through your own generator
- `yield from` will return any value stored in `StopIteration`

```
>>> def foo():
...     yield 1
...     yield 2
...     return 3
>>> def bar():
...     ret = yield from foo()
...     print("foo returned:", ret)
>>> for i in bar(): print(i)
1
2
foo returned: 3
```

Generator example: execution order

```
>>> def foo():
...     for _ in range(3):
...         yield input("Write something: ")
...     return "I was returned by foo()"
...
>>> def bar():
...     ret = yield from foo()
...     yield ret.upper()
...
```

```
>>> for i in bar():
...     print("I got:", i)
Write something: Alice
I got: Alice
Write something: Bob
I got: Bob
Write something: Foobar
I got: Foobar
I got: I WAS RETURNED BY FOO()
```

Inline generators

```
>>> [i * 2 for i in range(4) if i != 2]
[0, 2, 6]
>>> (i * 2 for i in range(4) if i != 2)
<generator object <genexpr> at 0x7f373cb3f6c0>
>>> list(i * 2 for i in range(4) if i != 2)
[0, 2, 6]
```

These are seriously amazing to work with.

Iterables - sequences

- An alternative way of defining iterables is by implementing the Sequence methods.
  - `.__len__()`
  - `.__getitem__()`
- `iter()` will be able to convert it into an iterator for you

AsyncIO

- AsyncIO is a module in the standard library, introduced in Python 3.4
- The syntax was extended in Python 3.5 to make it more intuitive
- It enables you to handle many different input/output streams simultaneously without resorting to threading
- To achieve this, AsyncIO runs a event loop which schedules coroutines to run at different times
- A coroutine is a glorified generator, which yields control back to the event loop while idle

Coroutines

- Coroutines are a language construct designed for concurrent operation.
- They use the halting mechanic of generators to allow for other code to run in the meantime

- Coroutines in Python 3.4:

```
@asyncio.coroutine
def hello_world():
    yield from asyncio.sleep(1)
```

- Python 3.5 added `async` and `await` to simplify this:

```
async def hello_world():
    await asyncio.sleep(1)
```

AsyncIO example: scheduling and concurrency

```
>>> import asyncio
>>> async def coro_1():
...     while True:
...         await asyncio.sleep(1)
...         print("coro_1")
...
>>> async def coro_2():
...     await asyncio.sleep(0.5)
...     while True:
...         await asyncio.sleep(1)
...         print("coro_2")
...
```

```
>>> event_loop = asyncio.get_event_loop()
>>> asyncio.ensure_future(coro_1())
>>> asyncio.ensure_future(coro_2())
>>> event_loop.run_forever()
coro_1
coro_2
coro_1
coro_2
coro_1
coro_2
coro_1
coro_2
```

AsyncIO example: return values

```
>>> import asyncio
>>> async def coro_sub():
...     await asyncio.sleep(1)
...     return 5
...
>>> async def coro_main():
...     ret = await coro_sub()
...     print("coro_sub returned", ret)
...     return 10
...
```

```
>>> event_loop = asyncio.get_event_loop()
>>> event_loop.run_until_complete(coro_main())
coro_sub returned 5
10
```

AsyncIO example: web development

- A real code snippet I've written recently. Using **sanic** as the webserver, **airspeed** as the templating engine and **aiopg** to interact with the database.

```
@app.route("/home")
@outputs_html
@with_template("frontpage.vm")
async def GET_frontpage(request, template):
    session = await get_session(request)
    user = await database.get_user(session)
    return template.merge(locals())
```

Example: Asyncio compared to synchronous code

Synchronous code:

```
def sync1():
        result = sync2()
        return result * 2

def sync2():
        result = io_operation("something")
        return result

sync1()
```

Asynchronous code:

```
import asyncio

async def coro1():
        result = await coro2()
        return result * 2

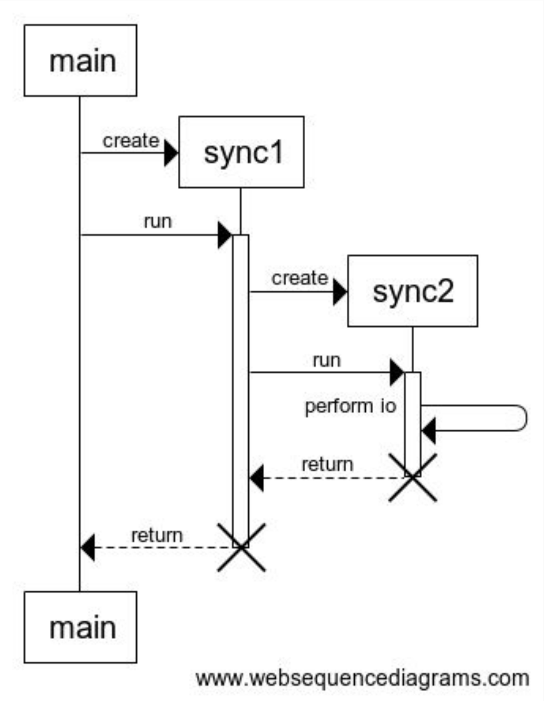
async def coro2():
        result = await io_operation("something")
        return result

asyncio.run_until_complete(coro1())
```

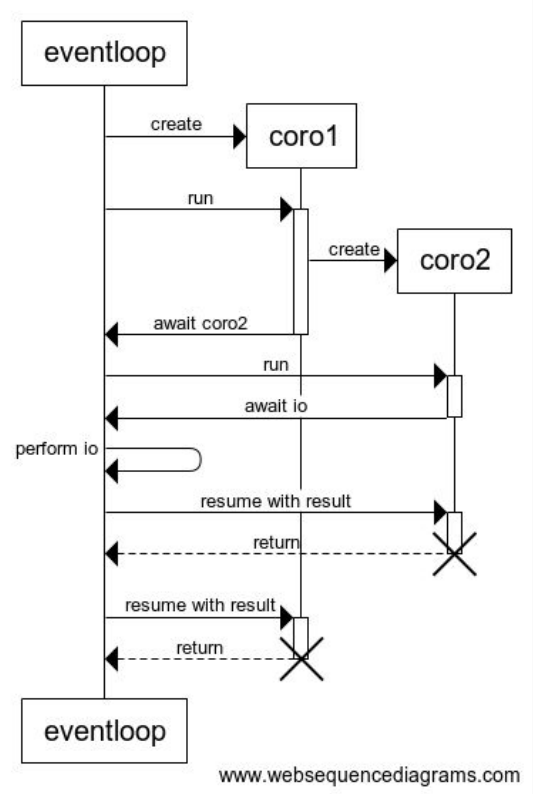
Almost the same, *right*?

Example: Asyncio compared to synchronous code, sequence diagrams

Synchronous code:



Asynchronous code:



Control often returns to the *eventloop*, allowing us to perform other tasks while awaiting IO

Why use asyncio?

- It’s *new, hip and cool*.
- it’s **built in**! unlike *curio* :(
- It is way easier to develop and debug than some of the other concurrent/asynchronous frameworks *i’m looking at you, TwistedMatrix!*
- It utilizes the available resources more efficiently than threading when dealing with IO
- There is an ever growing library of asyncio modules, capable of cooperating thanks to the common framework

Programvareverkstedet

- It’s at the second floor on Stripa at NTNU Gløshaugen, close by Adgangskontrollen.
- Need help learning or figuring out something programming related? We’d love to help you out!
- We have a neat server room, computer terminals, a fun community representing a great amount of computer knowledge!
- Open for *anyone* to just drop by whenever, without any obligations nor duties!

s.ntnu.no/apy20