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Python Advanced


Introduction

Program

Python Recap
Python Advanced Concepts

File Formats
Pickle
XML
JSON

Database Access
ORM
SqlAlchemy

Web Frameworks
Pyramid
Django
Flask

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Topics

- Pythonic / Idiomatic Python
- OO - associations
- virtual environments
- type hinting
- logging
- zipfile
- pylint
- docstrings
- pydoc
- unit testing
- File I/O
- Concurrency
- GUI
- configparser
- git & github
- functools
- itertools
- pathlib
- shutil
- dateutil, calendar, arrow
- database access
- web applications
- executables

Python Basics

- Built-in numeric types: bool, int, float, complex
- Operators: arthimetic, comparative, boolean
- Strings: concatenation, string methods, formating, unicode
- Flow statements: while, for, if-elif-else
- Functions: arguments, default values, variadic arguments, keyword arguments, return value, lambda
- Built-in functions
- Reading from and writing to files, context manager
- Lists: indexing, slicing, modification, unpacking, comprehesion
- Dicts: creation, modification, iterating
- Object Orientation: classes, objects, methods and attributes

Advanced Python

Pythonic / Idiomatic Python

- PEP 8 – Style Guide for Python Code https://peps.python.org/pep-0008/

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pip

```
Usage:
  pip <command> [options]

Commands:
  install                     Install packages.
  download                    Download packages.
  uninstall                   Uninstall packages.
  freeze                      Output installed packages in requirements format.
  inspect                     Inspect the python environment.
  list                        List installed packages.
  show                        Show information about installed packages.
  check                       Verify installed packages have compatible dependencies.
  config                      Manage local and global configuration.
  search                      Search PyPI for packages.
  cache                       Inspect and manage pip's wheel cache.
  index                       Inspect information available from package indexes.
  wheel                       Build wheels from your requirements.
  hash                        Compute hashes of package archives.
  completion                  A helper command used for command completion.
  debug                       Show information useful for debugging.
  help                        Show help for commands.
```

```
$ pip list > requirements.txt
$ pip install -r requirements.txt
```

Project structure

- https://docs.python-guide.org/writing/structure/

```
"""Script to ..."""

import sys

def main():
  """Main entry point for the script."""
  pass

if __name__ == '__main__':
  sys.exit(main())
```

```
helloworld/
|
├── bin/
|
├── docs/
|   ├── hello.md
|   └── world.md
|
├── helloworld/
|   ├── __init__.py
|   ├── runner.py
|   ├── hello/
|   |   ├── __init__.py
|   |   ├── hello.py
|   |   └── helpers.py
|   |
|   └── world/
|       ├── __init__.py
|       ├── helpers.py
|       └── world.py
|
├── data/
|   └── input.csv
|
├── tests/
|.  ├── hello
|   |   ├── helpers_tests.py
|   |   └── hello_tests.py
|   |
|   └── world/
|       ├── helpers_tests.py
|       └── world_tests.py
|
├── .gitignore
├── LICENSE
├── README.md
├── requirements.txt
├── setup.py
└── venv
```

Import

- import in a script
- vs
- import in a package

```
try:
    from .encryption import Encryption

except ImportError:
    from encryption import Encryption
```

https://realpython.com/python-import

Virtual Environments

Python virtual environments aim to provide a lightweight, isolated Python environment

- venv

```
$ python -m venv venv

$ venv\Scripts\activate            # windows
$ source venv/bin/activate         # macos

$ deactivate
```

- virtualenv
  - The package is a superset of venv, which allows you to do everything that you can do using venv, and more

Conda Environments

- Conda Package and Environment Manager

- If you're working in the data science space and with Python alongside other data science projects, then conda is an excellent choice that works across platforms and languages.

- conda

```
$ conda create -n new_environment
$ conda activate new_environment
$ conda deactivate
```

Type Hinting

- Type hinting is a formal solution to statically indicate the type of a value within your Python code. It was specified in **PEP 484** and introduced in **Python 3.5**.

- Python's type hints provide you with optional static typing to leverage the best of both static and dynamic typing.

```
def headline(text: str, align: bool = True) -> str:
    if align:
        return f"{text.title()}\n{'-' * len(text)}"
    else:
        return f" {text.title()} ".center(50, "o")
```

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Variadic arguments

- *args
- **kwargs

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Decorators

- A decorator is a function that takes another function and extends the behavior of the latter function without explicitly modifying it.

- Functions are first-class citizens:
  - functions can be passed around and used as arguments.
  - functions can be defined inside other functions. Such functions are called inner functions.
  - functions can be returned as return values.

```
def my_decorator(f):
    def wrapper(*args, **kwargs):
        # do something
        return_value = f(*args, **kwargs)
        # do something
        return return_value
    return wrapper
```

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Functools

- higher order functions
- functional programming: map, filter, sorted, reduce
- closure
- partial
- decorators

Closures

- A closure is a function defined within an other function
- The inner function retains the variables during definition

```
def say():
    greeting = 'Hello'

    def display():
        nonlocal greeting
        print(greeting)

    return display
```

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Classes

- Decorators
  - @classmethod
  - @staticmethod
  - @property
  - @<property>.setter
- Inheritance
  - super()
  - multiple inheritance, MRO

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Functional Programming

- Pure functions
- No side-effects
  - no printing
  - no globals
- Built-in functions
  - map
  - filter
  - sorted
  - reduce
- Lambda

Generator expression

- Generator expression (x**2 for x in range(100))

```
# list comprehension
doubles = [2 * n for n in range(50)]

# generator expression
doubles = (2 * n for n in range(50))

# same as the list comprehension above
doubles = list(2 * n for n in range(50))
```

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Generator functions

- The keyword **yield** specifies a generator function
- When the yield keyword is hit the function returns a result
- The next time the function is called the function continues where it left off

```
import random

def random_order1(numbers):
    random.shuffle(numbers)
    for number in numbers:
        yield number

def random_order2(numbers):
    random.shuffle(numbers)
        yield from numbers
```

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Logging facility for Python

- import **logging**
- Setup with **basicConfig**
- Logging Levels: DEBUG, INFO, WARNING, ERROR, CRITICAL

```
import logging

logging.basicConfig(
    filename = None, # or to a file 'example.log',
    level = logging.ERROR,
    format = '%(asctime)s.%(msecs)03d - %(message)s',
    datefmt = '%Y-%m-%dT%H:%M:%S')

logging.debug('This message should go to the log file')
logging.info('So should this')
logging.warning('And this, too')
logging.error('Watch out!')
logging.critical('ERROR!!!!!')
```

Pylint

- Pylint is a **static code analyser** for Python
- Pylint analyses your code without actually running it. It checks for errors, enforces a coding standard, looks for code smells, and can make suggestions about how the code could be refactored.
- It can also be integrated in most editors or IDEs.
- pylint my_script.py

Docstrings

- Best practices
  - All modules, classes, methods, and functions, including the __init__ constructor in packages should have docstrings.
  - Descriptions are capitalized and have end-of-sentence punctuation.
  - Always use """Triple double quotes.""" around docstrings.
  - Docstrings are not followed by a blank line.

- Conventions for multi-line docstrings
  - Sphinx style
  - Google Format
  - NumPy Format

```
"""[Summary]

:param [ParamName]: [ParamDescription], defaults to [DefaultParamVal]
:type [ParamName]: [ParamType](, optional)
...
:raises [ErrorType]: [ErrorDescription]
...
:return: [ReturnDescription]
:rtype: [ReturnType]
"""
```

pydoc

- Documentation generator and online help system

- The built-in function help() invokes the online help system in the interactive interpreter, which uses pydoc to generate its documentation as text on the console.

- In order to find objects and their documentation, pydoc imports the module(s) to be documented. Therefore, any code on module level will be executed on that occasion. Use an `if __name__ == '__main__':` guard to only execute code when a file is invoked as a script and not just imported.

```
$ pydoc sys
```

unittest - Unit testing framework

- There is also an **assert** statement

```
import unittest


class TestStringMethods(unittest.TestCase):

    def test_upper(self):
        self.assertEqual('foo'.upper(), 'FOO')

    def test_isupper(self):
        self.assertTrue('FOO'.isupper())
        self.assertFalse('Foo'.isupper())


if __name__ == '__main__':
    unittest.main()
```

assertEqual(a, b)
assertNotEqual(a, b)
assertTrue(x)
assertFalse(x)
assertIs(a, b)
assertIsNot(a, b)
assertIsNone(x)
assertIsNotNone(x)
assertIn(a, b)
assertNotIn(a, b)
assertIsInstance(a, b)
assertNotIsInstance(a, b)

File I/O

json - JavaScript Object Notation

- JSON encoder and decoder

json.dump(object, file)
json.dumps(object)
json.load(file)
json.loads(string)

```
import json

s = json.dumps([1,2,3,{'4': 5, '6': 7}])

with open('bestand.json', 'w') as f:
    json.dump([1,2,3,{'4': 5, '6': 7}], f)

json.loads('[1,2,3,{"4":5,"6":7}]')
```

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pickle - Python object serialization

- A **shelf** is a persistent, dictionary-like object that stores any arbitrary Python that can be pickled.

pickle.dump(object, file)

pickle.dumps(object)

pickle.load(file)

pickle.loads(string)

```
import pickle

class User:
    def saveToPickle(self):
        with open('user.pickle','wb') as f:
            pickle.dump(self, f)
    def loadFromPickle(self):
        with open('user.pickle','rb') as f:
            self.__dict__.update(pickle.load(f).__dict__)
    @classmethod
    def createFromPickle(cls):
        with open('user.pickle','rb') as f:
            return pickle.load(f)
```

xml

- The **xml.etree.ElementTree** module implements a simple and efficient API for parsing and creating XML data.
- This module provides limited support for **XPath** expressions for locating elements in a tree. https://www.w3schools.com/xml/xpath_intro.asp
- ElementTree provides a simple way to build XML documents and write them to files.

```
import xml.etree.ElementTree as ET

tree = ET.parse('data.xml')
root = tree.getroot()

print(root.attrib)

for element in root.findall('//name'):
    print(element.text)
```

GUI

- tkinter
- pyqt

configparser

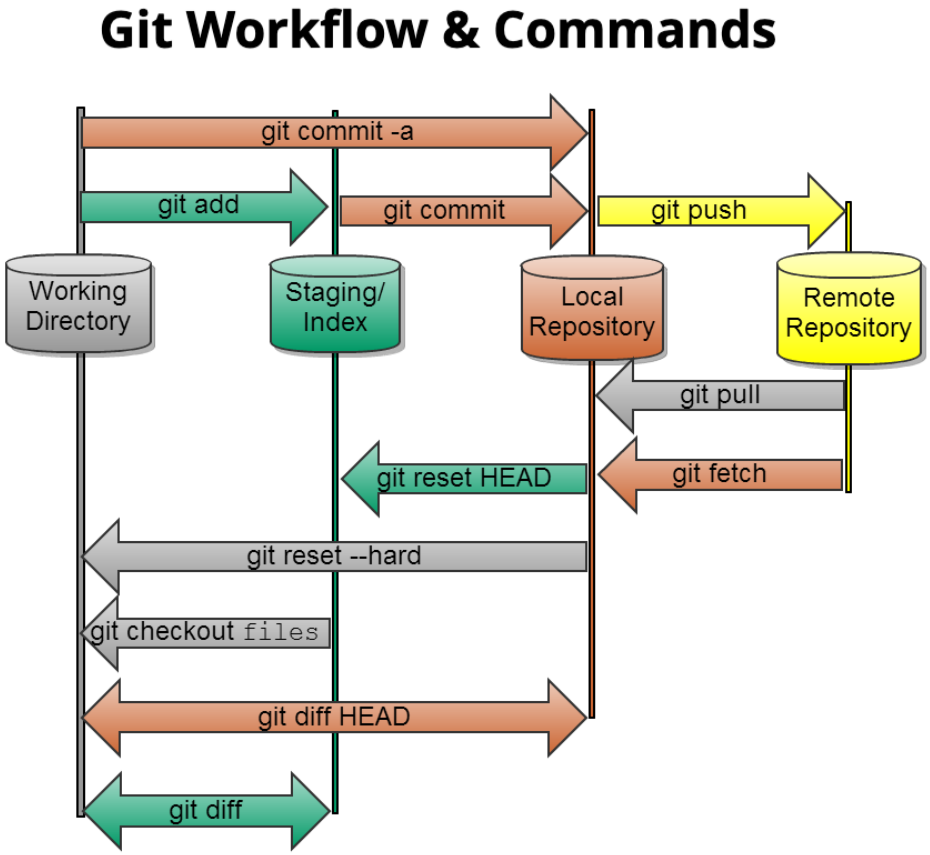
- This module provides the ConfigParser class which implements a basic configuration language which provides a structure similar to what's found in Microsoft Windows INI files.

```
import configparser
config = configparser.ConfigParser()
config['DEFAULT'] = {'ServerAliveInterval': '45',
                     'Compression': 'yes',
                     'CompressionLevel': '9'}
config['bitbucket.org'] = {}
config['bitbucket.org']['User'] = 'hg'
config['topsecret.server.com'] = {}
topsecret = config['topsecret.server.com']
topsecret['Port'] = '50022' # mutates the parser
topsecret['ForwardX11'] = 'no' # same here
config['DEFAULT']['ForwardX11'] = 'yes'
with open('example.ini', 'w') as configfile:
    config.write(configfile)
```

```
[DEFAULT]
ServerAliveInterval = 45
Compression = yes
CompressionLevel = 9
ForwardX11 = yes
[bitbucket.org]
User = hg
[topsecret.server.com]
Port = 50022
ForwardX11 = no
```

git & github

- Git is a free and open source distributed version control system




```
$ git config --global user.name "My Name"
$ git config --global user.email "myname@gmail.com"

$ git init Demo
$ git clone URL

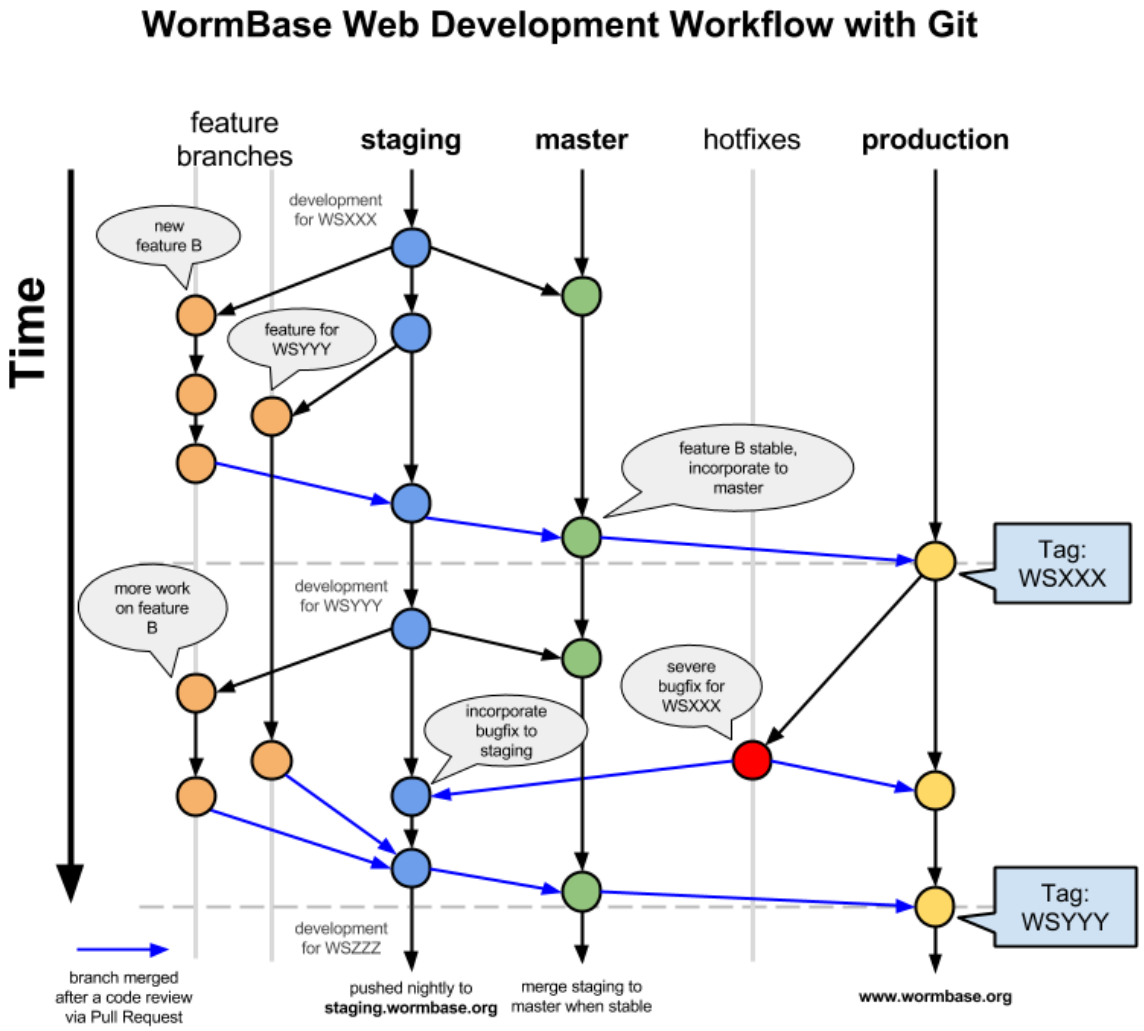
$ git add Filename

$ git commit -m "Commit Message"

$ git status

$ git push origin master
$ git push --all
$ git pull URL
```

GIT Branches & Workflow



itertools

pathlib

shutil

datetime - Basic date and time types

- The datetime module supplies classes for manipulating dates and times.

class datetime.date
class datetime.time
class datetime.datetime
class datetime.timedelta
class datetime.tzinfo
class datetime.timezone

strftime
strptime

```
from datetime import date

d = date(2020, 2, 28)

print(d.strftime('%Y-%m-%d'))
```

dateutil, calendar, arrow

- The *dateutil* module provides powerful extensions to the standard *datetime* module, available in Python.

database access

- PEP 249 - Database API Specification 2.0

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sqlite3

- DB-API 2.0 interface for SQLite databases

```
import sqlite3

conn = sqlite3.connect('example.db')
c = conn.cursor()

c.execute("""CREATE TABLE stocks
          (date text, trans text, symbol text, qty real, price real)""")

c.execute("""INSERT INTO stocks
          VALUES ('2006-01-05', 'BUY', 'RHAT', 100, 35.14)""")

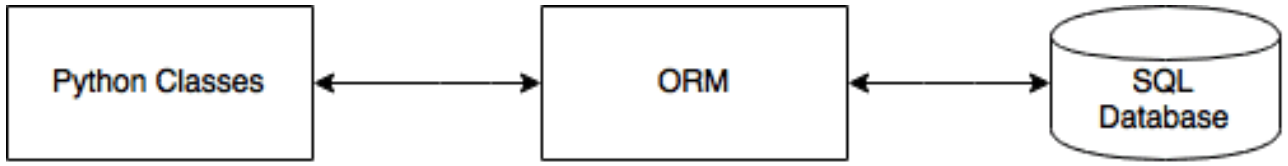
conn.commit()

for row in c.execute('SELECT * FROM stocks ORDER BY price'):
     print(row)

conn.close()
```

SqlAlchemy

- The Python SQL Toolkit and Object Relational Mapper



SQLAlchemy

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web applications

- django
- flask
- pyramid
- fastapi

- dash
- streamlit

django

MVC Framework

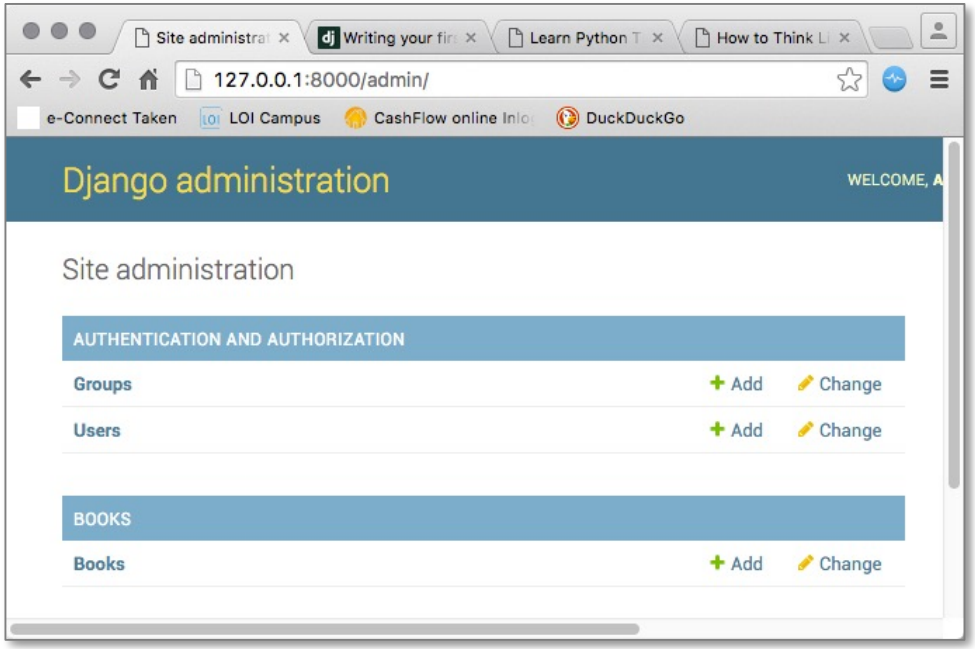
Models

Object-Relational Mapping

URL Mapping

Views

HTML Templates



Command line bootstrap:

```
$ mkdir django-demo
$ cd django-demo
$ virtualenv -p python3.5 venv
$ . venv/bin/activate
$ pip install django
$ django-admin
$ django-admin startproject demo
$ python manage.py createsuperuser
$ python manage.py startapp books
$ python manage.py makemigrations
$ python manage.py migrate
$ python manage.py runserver
```

executables

- shebang #!/usr/bin/env python3
- py2exe windows
- py2app macos

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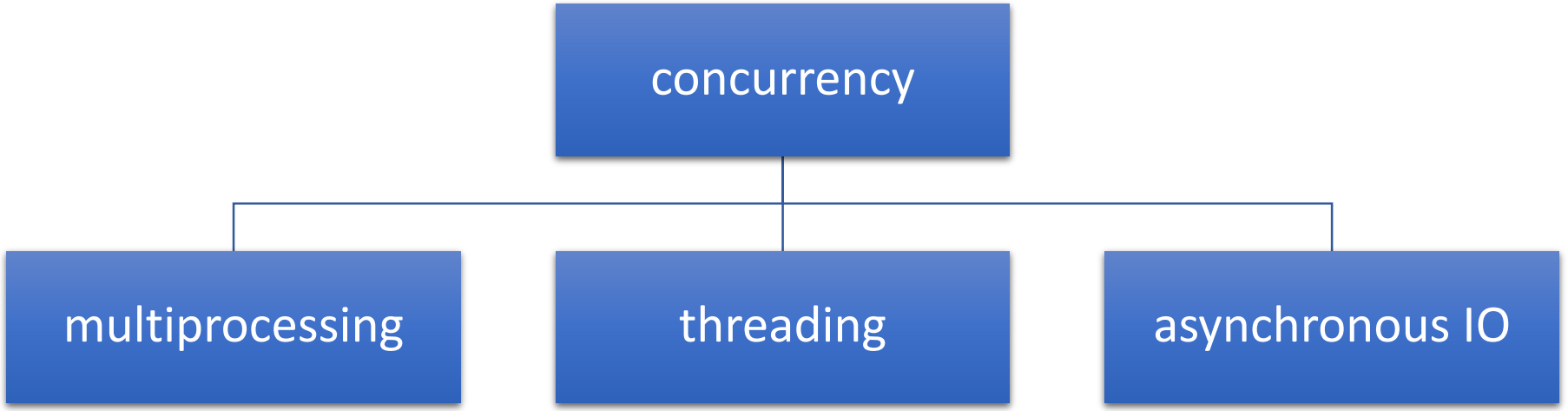
Concurrency

- Threading
- Asynchronous
- Multiprocessing

Concurrency



Python Standard Library:

- **multiprocessing** package
- **threading** package
- **asyncio** package and **async**/**await** keywords (introduced in Python 3.4)

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Comparison

	Multiprocessing	Threading	Asynchronous IO
Package	multiprocessing	threading	asyncio
Class	Proces	Thread	Coroutine
Python	Class Proces	Class Thread	Keywords async, await
Data sharing	Message	Shared data	
Usage	CPU intensive	IO intensive	IO intensive

Proces versus Thread

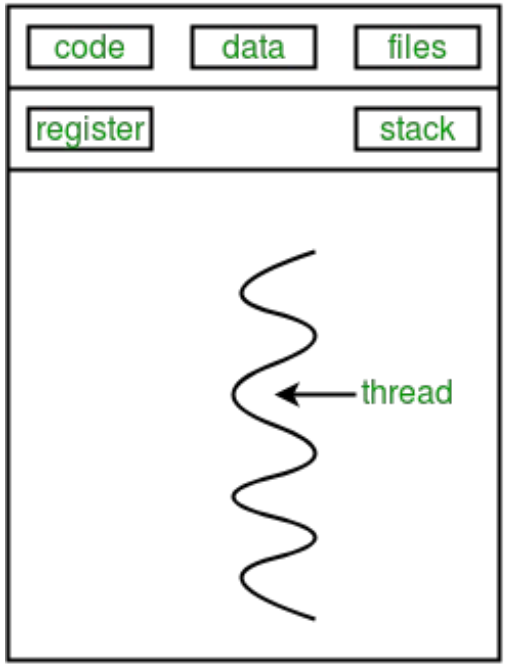
- True parallelism in Python is achieved by creating multiple processes, each having a Python interpreter with its own separate GIL.

Process	Thread
processes run in separate memory (process isolation)	threads share memory
uses more memory	uses less memory
children can become zombies	no zombies possible
more overhead	less overhead
slower to create and destroy	faster to create and destroy
easier to code and debug	can become harder to code and debug

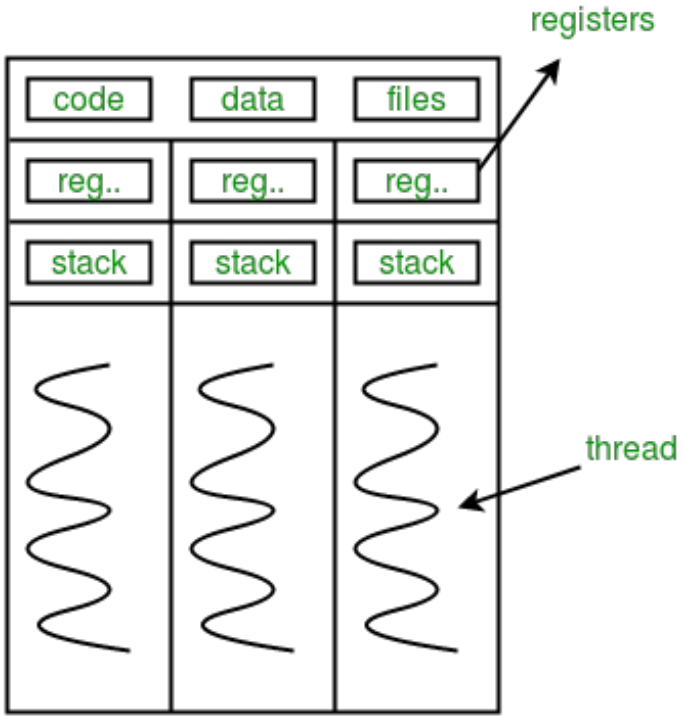
Python GIL

- A **global interpreter lock (GIL)** is a mechanism used in Python interpreter to synchronize the execution of threads so that only one native thread can execute at a time, even if run on a multi-core processor.
- The C extensions, such as numpy, can manually release the GIL to speed up computations. Also, the GIL released before potentionally blocking I/O operations.
- Note that both Jython and IronPython do not have the GIL.

Threading



single-threaded process



multithreaded process

threading - Thread-based parallelism

- **Thread**
  - start
  - run
  - join
  - name
- **active_count**
- **current_thread**
- **main_thread**

```
import time
from threading import Thread

def myfunc(i):
    print "sleeping 5 sec from thread %d" % i
    time.sleep(5)
    print "finished sleeping from thread %d" % i

for i in range(10):
    t = Thread(target=myfunc, args=(i,))
    t.start()
```

asyncio

- At the heart of async IO are **coroutines**. A coroutine is a specialized version of a Python generator function.

```
import asyncio

async def count():
    print("One")
    await asyncio.sleep(1)
    print("Two")

async def main():
    await asyncio.gather(count(), count(), count())

if __name__ == "__main__":
    import time
    s = time.perf_counter()
    asyncio.run(main())
    elapsed = time.perf_counter() - s
    print(f"{__file__} executed in {elapsed:0.2f} seconds.")
```

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multiprocessing

- The multiprocessing library is based on spawning Processes.
- A process starts a fresh Python interpreter thereby side-stepping the Global Interpreter Lock
- The multiprocessing module allows the programmer to fully leverage multiple processors on a given machine.

```
from multiprocessing import Process

def f(name):
    print('hello', name)

if __name__ == '__main__':
    p = Process(target=f, args=('bob',))
    p.start()
    p.join()
```

Implementations

- CPython reference implementation
- IronPython (Python running on .NET)
- Jython (Python running on the Java Virtual Machine)
- PyPy (A fast python implementation with a JIT compiler)
- Stackless Python (Branch of CPython supporting microthreads)
- MicroPython (Python running on micro controllers)

Python DBI API 2.0

- connect
- cursor
- execute

RDBMS

• SQLite	sqlite3
• Microsoft SQL Server	pyodbc
• Oracle	
• PostgreSQL	psycopg2
• MySQL	mysql-connector-python

NoSQL

NoSQL databases are more flexible than relational databases. In these types of databases, the data storage structure is designed and optimized for specific requirements. There are four main types for NoSQL libraries:

- Document-oriented
- Key-value pair
- Column-oriented
- Graph

Python NoSQL:

- MongoDB
- Redis
- Cassandra
- Neo4j

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SQL

- CREATE TABLE
- ALTER TABLE
- DROP TABLE
- INSERT
- SELECT
- UPDATE
- DELETE

- CRUD
  - Create
  - Read
  - Update
  - Delete

- LIMIT clause
- FROM clause
- JOIN clause
- WHERE clause
- ORDER BY clause
- GROUP BY clause

SQLite

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PostgreSQL

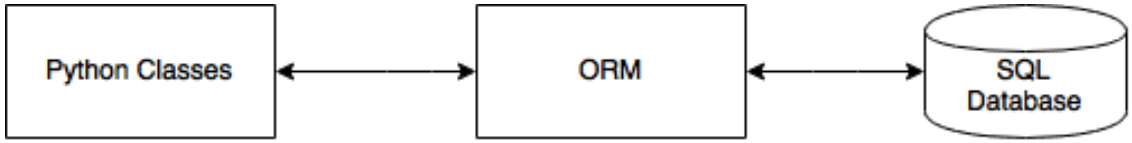
Links

- https://pythonspot.com/python-database/
- https://www.geeksforgeeks.org/python-database-tutorial/
- https://www.tutorialspoint.com/postgresql/index.htm

Links

- https://www.geeksforgeeks.org/python-database-tutorial/

SqlAlchemy



Student Class in Object Model

```
@Entity
@Table(name = "students")
public class Student {

    @Id
    @GeneratedValue
    Long id;

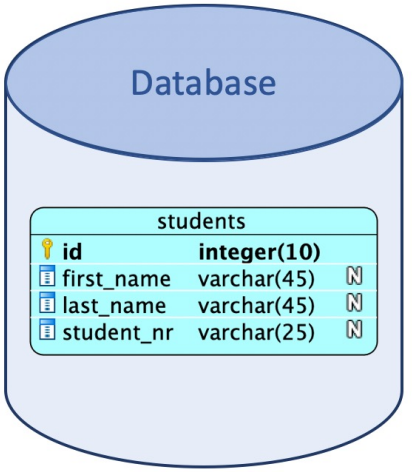
    @Column(name = "first_name")
    String firstName;

    @Column(name = "last_name")
    String lastName;

    @Column(name = "student_nr")
    String studentNr;

}
```

Student Table in Relational Model



requests – HTTP for Humans

- **Requests** is an elegant and simple HTTP library for Python, built for human beings.

```
import requests

url = "http://api.openweathermap.org/data/2.5/weather"
url += "?appid=d1526a9039658a6f76950cff21823aff"
url += "&units=metric"
url += "&mode=json"
url += "&q=New York"

response = requests.get(url)
if (response.status_code == 200):
    body = response.text
    decoded = response.json()
    temperature = decoded['main']['temp']
else:
    print("Error for city %s" % (city))
```

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Web Frameworks

- Django
- Flask
- Pyramid
- Bottle
- Sierra
- FastAPI

Web Framework

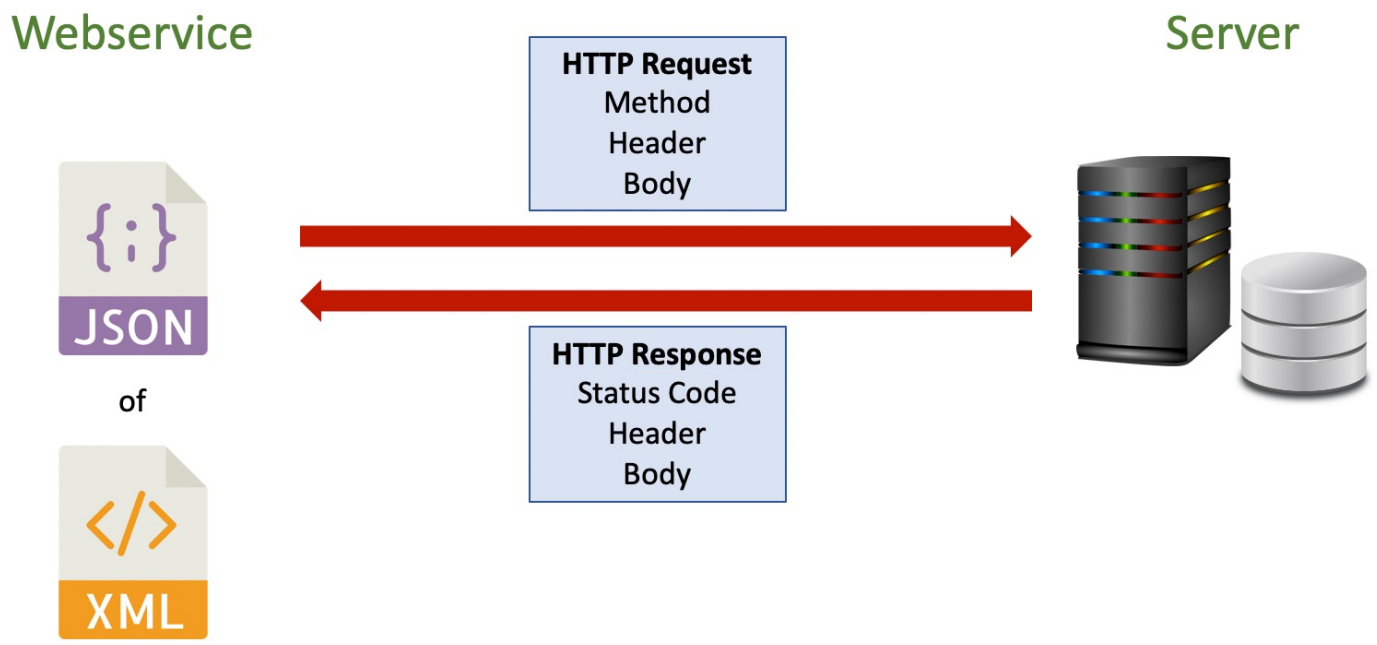
- Routing
- Database ORM
- Templating

Front-end development
HTML
CSS
Javascript
Media

Back-end development
Webserver
Programming Language
Web Framework
Database

RESTful

- Client – Server
- Http Verbs – Get, Post, Put, Delete => CRUD
- Payload – Data - JSON



django

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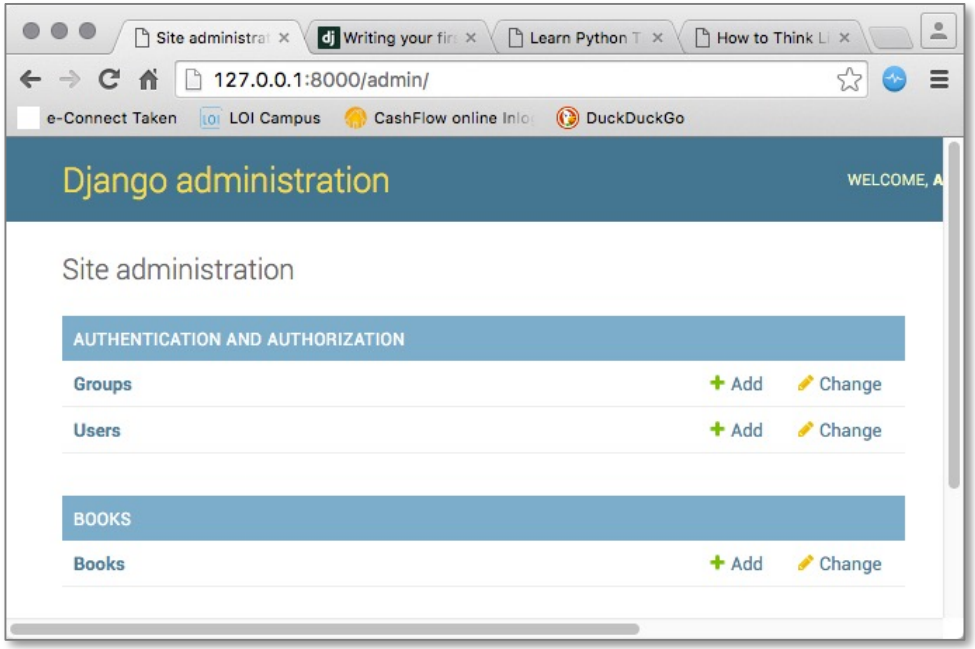

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```

Flask

- **Flask** is a micro web framework written in Python. It is classified as a microframework because it does not require particular tools or libraries.[2] It has no database abstraction layer, form validation, or any other components where pre-existing third-party libraries provide common functions. However, Flask supports extensions that can add application features as if they were implemented in Flask itself. Extensions exist for object-relational mappers, form validation, upload handling, various open authentication technologies and several common framework related tools.

FastAPI

GUI Frameworks

- **TkInter** - The traditional Python user interface toolkit.

- **PyQt** - Bindings for the cross-platform Qt framework.
- **PySide** - PySide is a newer binding to the Qt toolkit
- **wxPython** - a cross-platform GUI toolkit that is built around wxWidgets
- **Win32Api** - native window dialogs
- **PyMsgBox**

- **Dash**
- **Jupyter Widgets**

tkinter

- The tkinter package (“Tk interface”) is the standard Python interface to the Tk GUI toolkit.
- There are also Standard Dialogs


```
import tkinter as tk
import tkMessageBox

top = tk.Tk()

def hello():
     tkMessageBox.showinfo("Say Hello", "Hello World")

btn1 = tk.Button(top, text = "Say Hello", command = hello)
btn1.pack()

top.mainloop()
```

tkinter

- widgets

- Layout Managers
  - pack
  - grid
  - place

Tkinter Frame
Tkinter Button
Tkinter Label
Tkinter Entry
Tkinter Radio Button
Tkinter Check Button
Tkinter Combobox
Tkinter Menu Button
Tkinter Toplevel
Tkinter Scrollbar
Tkinter Menu
Tkinter List Box
Tkinter Text Widget
Tkinter Canvas
Tkinter Scale
Tkinter LabelFrame
Tkinter SpinBox
Tkinter Color Chooser

Distributions

- py2exe
- py2app