UE 803 - Data Science

Session 1: setting up our working environment

Yannick Parmentier - Université de Lorraine / LORIA

Loria
Laboratoire lorrain de recherche
en informatique et ses applications

cnrs

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Introduction

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Origins :

- close relation to *statistics* ("data analysis" field created by US mathematician John Tukey in 1962)
- 2002 : launching of the *Data Science Journal*

Introduction (continued)

What happened in the early 2000s ?

Introduction (continued)

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- a **cultural** evolution

> There are two cultures in the use of statistical modeling to reach conclusions from data. One assumes that the data are generated by a given stochastic data model. The other uses **algorithmic models** and treats the **data mechanism as unknown**.

(Leo Breitman, 2001)

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(Leo Breitman, 2001)

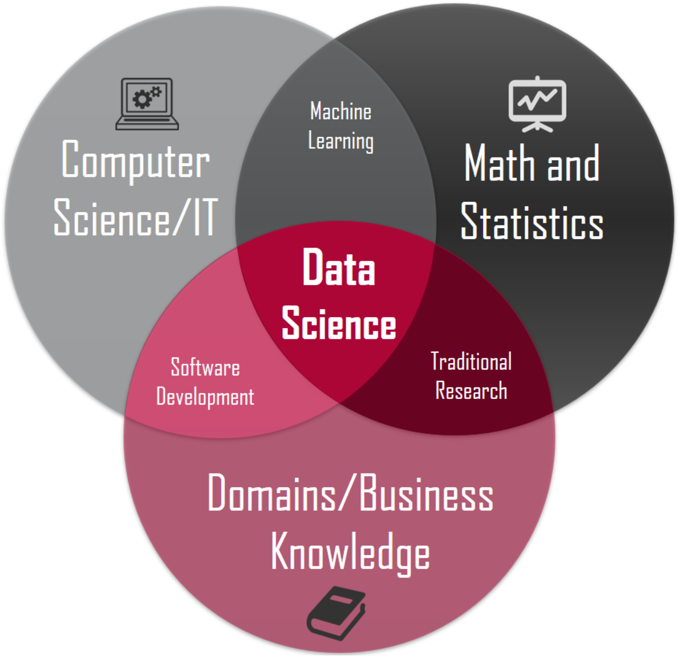
- a **technical** evolution
    - Big Data
    - Internet of Things

Introduction (continued)

In other terms :

> Data Science is about drawing useful conclusions from large and diverse data sets through **exploration**, **prediction**, and **inference**.

Source: inferentialthinking.com



Statistics : finding **patterns**

IT : **scaling up**, making predictions

Domain : **interpreting** results

Introduction (continued)

Classical workflow :

1) **Collect data**

2) **Clean and visualize data**

3) **Extract** underlying **knowledge** (data *features*)

4) **Apply Machine Learning** algorithms (e.g. linear regression, clustering, etc.) to make predictions

5) **Evaluate** the quality of the prediction

Course organization

- 60-hour course splitted into 3-hour sessions
- Each session includes practical exercises
- Evaluation is based on :
    - 3 reports on specific practical sessions
    - A final project (source code + oral defense)
- Implementation is done using the Python 3 programming language

Today's menu

- Setting up our working environment
- Hands on Python (again)
  - build-in data-types
  - Object-Oriented Programming

Data science with Python

Note it could have been R !

The Python ecosystem

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  - a *platform* (Operating System),
  - a *language version* (interpreter),
  - and *librairies* (with potential compatibility issues)

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→ How to deal with all these sources of **heterogeneity** ?

Setting up a Python environment

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- Virtual environments can be **created** and **activated**/deactivated using dedicated **commands**:

```
$ conda create --name myenv python=3.7
$ conda activate myenv
```

Setting up a Python environment (continued)

- From the terminal, libraries can be **searched** and then **installed** as follows

```
(myenv) ...$ conda search library_name
(myenv) ...$ conda install library_name
```

- Alternatively, libraries may be installed within conda virtual environments using `pip`

```
(myenv) ...$ pip install <library>
```

- Libraries installed by `conda` can be enumerated via

```
(myenv) ...$ conda list
```

→ Want more conda commands ? see conda cheatsheet 🔗

Programming in Python

- Option #1: in an **interactive** interpreter

```
$ python3
Python 3.6.7 (default, Oct 22 2018, 11:32:17)
[GCC 8.2.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> print(3)
3
>>>
```

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```

- Option #2: **in a source file**

```
python my_file.py
```

`my_file.py` can be edited by whatever editor you like : emacs, vim, geany, spyder, ...

Programming in Python (continued)

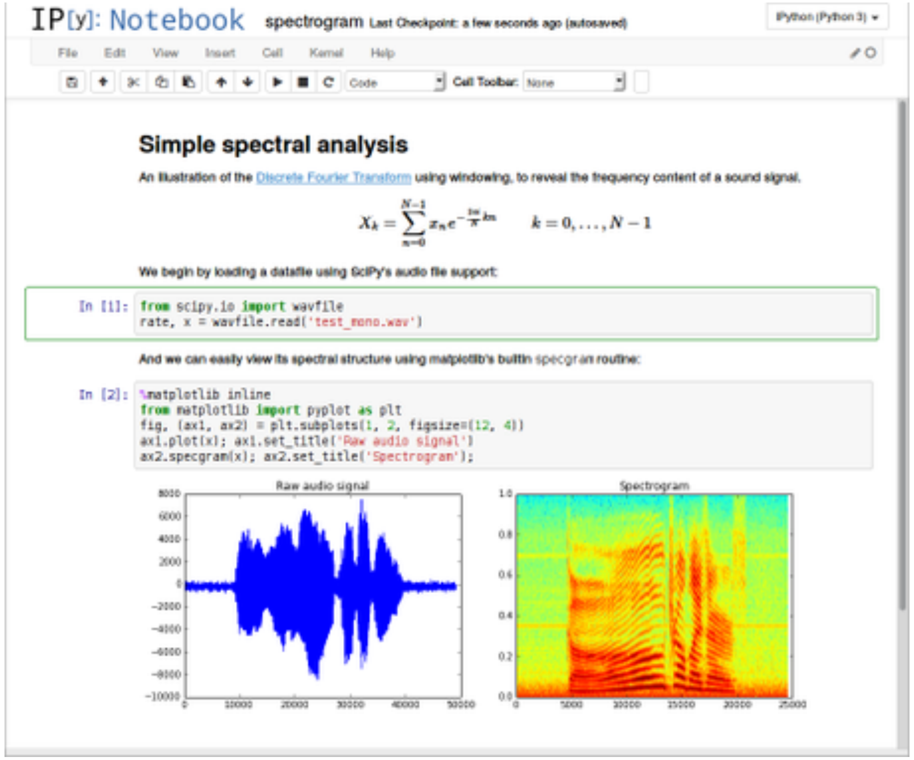
- Option #3: in an **integrated development environment** (IDE)
  - **edit *and* run** code from the same interface
- Example: Jupyter Notebook 🔗 (formerly iPython)
  - rich edition capacities **for code documentation** (e.g. formatted comments, images)
  - code and documentation are located **in a single file** (aka *literate programming*) called a **notebook**
  - Notebooks are made of blocks (aka *cells*) containing either **python code** or **markdown** + LaTeX **texts**

Programming in Python (continued)

- To **launch Jupyter from a terminal**:

```
(myenv) ...$ jupyter notebook
```

- Results :
  - web-browser displaying local files
  - notebooks corresponds to `.ipynb` files
  - hit `Ctrl+Shift` to interpret cells



Simple spectral analysis

An illustration of the Discrete Fourier Transform using windowing, to reveal the frequency content of a sound signal.

$$X_k = \sum_{n=0}^{N-1} x_n e^{-\frac{2\pi i}{N} kn} \qquad k = 0, \ldots, N-1$$

We begin by loading a datafile using SciPy's audio file support:

```
In [1]: from scipy.io import wavfile
        rate, x = wavfile.read('test_mono.wav')
```

And we can easily view its spectral structure using matplotlib's builtin specgram routine:

```
In [2]: %matplotlib inline
        from matplotlib import pyplot as plt
        fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(12, 4))
        ax1.plot(x); ax1.set_title('Raw audio signal')
        ax2.specgram(x); ax2.set_title('Spectrogram');
```

Working with Python 3

Recall

- Python is :

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    - *indentation-sensitive*
    - a *pass-by-reference* language
    - *mutli-paradigm*
        - imperative
        - functional
        - object-oriented

Recall (continued)

- Rich built-in types :
  - int, float
  - boolean
  - string
  - list
  - dictionaries
  - None
  - *etc.*

Recall (continued)

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```
>>> "hello"
'hello'
>>> print("hello")
hello
>>> type("hello")
<class 'str'>
>>>
```

Recall (continued)

- Type checking (with precise error messages!)

```
>>> 1 + 2.3
3.3
>>> True + 2.3
3.3
>>> "hello" + 12
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: Can't convert 'int' object to str implicitly
>>>
```

Recall (continued)

- expressive language
  - conditions, loops
  - (named / unnamed, first-class) functions
  - (heterogeneous) lists (aka dynamic arrays)
  - dictionaries (aka associative arrays)
  - (non-mutable) tuples
  - lazy iterators (cf yield)

Recall (continued)

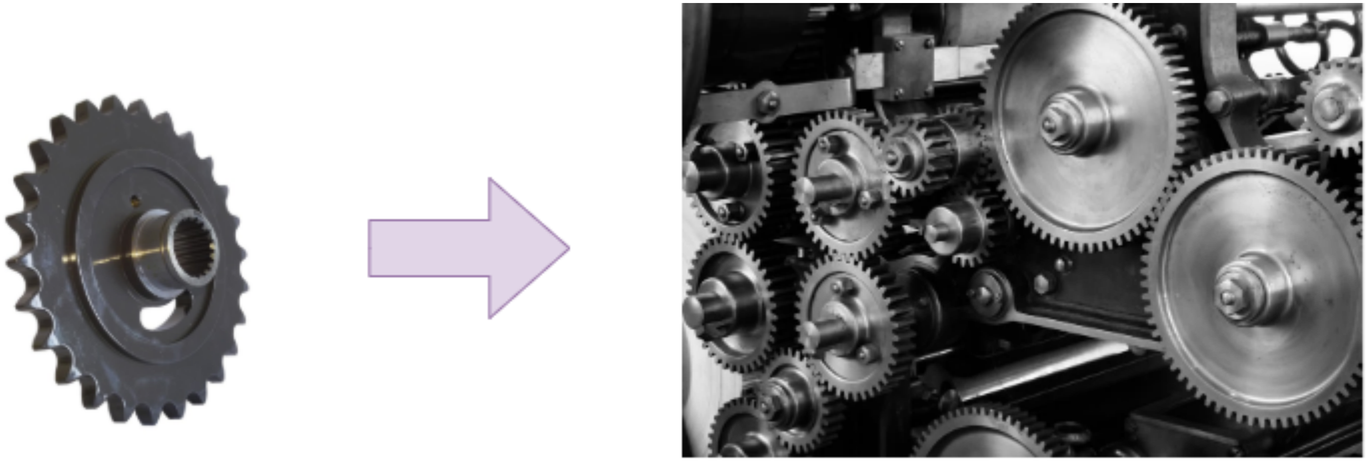
- and many very useful libraries
  - SCIentific PYthon toolkits (SciPy)
  - NL ToolKit (NLTK)
  - plotting (e.g. matplotlib)
  - window making (e.g TkInter, appJar)
  - game development (e.g pygame)
  - and much more

See also How to think like a computer scientist : Interactive Edition 🔗

Object-oriented Programming

From functional python

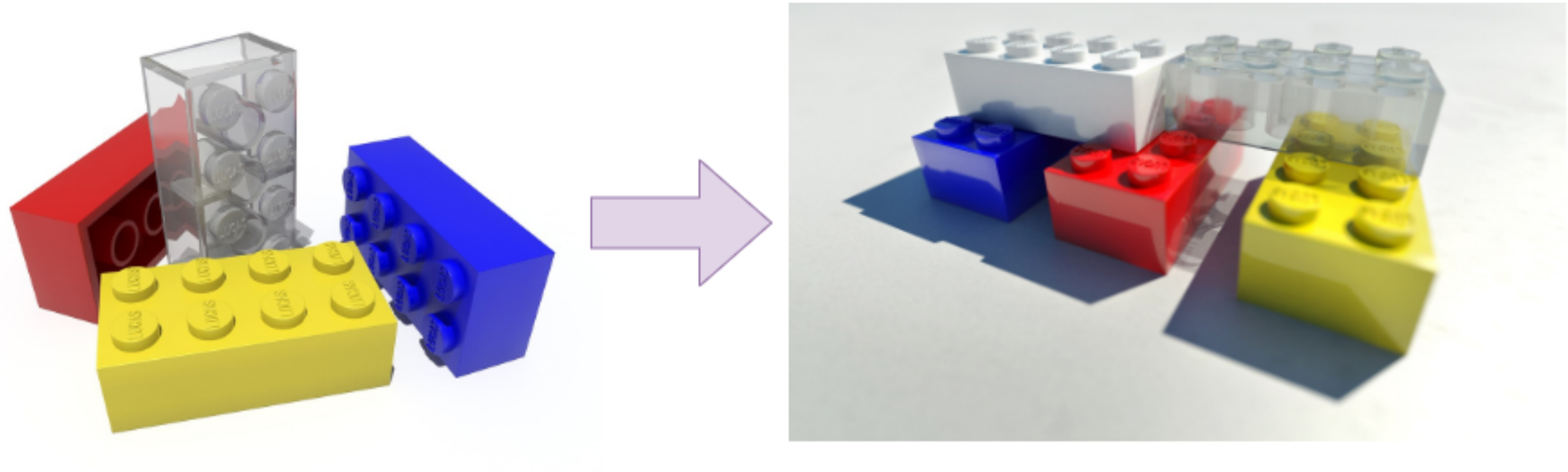
Focus on data *processings*



```
y = len(list(map(lambda x : x + 1, [1,2,3,4])))
```

To object-oriented python

Focus on data *types*



```
l = [1,2,3,4]
l.reverse()
```

Object-oriented programming

- *Data types* corresponds to **classes**
- *Classes* are made of **attributes** (variables) and **methods** (functions)
- A given data *instance* is called an **object**
- *Classes* can be defined locally or in **modules** (files)
- A program (python *main* script) can instantiate classes defined in accessible modules

Example

In a file named e.g. `Foo.py`, let us define a class `Foo` made of an attribute `bar` and three methods `__init__`, `__str__` and `concat`:

```python
class Foo:

  def __init__(self):
    self.bar = 'toto'

  def __str__(self):
    return self.bar + '!'

  def concat(self, s):
    self.bar += s
```

Example (continued)

Let us instantiate this class (object `x`) directly in `Foo.py`:

```python
if __name__=='__main__':
  x = Foo()
  print(x)
  x.concat('tata')
  print(x)
```

Finally, let us run this program by invoking:

```
python3 Foo.py
```

We will get:

```
toto!
tototata!
```

Sharing code

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Many ways to share documents :

- USB sticks
- Emails
- Cloud-hosted drives (owncloud, dropbox, google drive, microsoft one, ...)

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How to keep track of modifications ?

- complex file naming schemes

How to publish modifications ?

Introducing versioning

- A long history of **Version Control Systems** (CVS, SVN, Git, Darcs, Mercurial, ...)
- Versioning and sharing documents → **Development forge** (gitlab, github, bitbucket ...)
- Two main families :
    - centralized vs decentralized VCS
- Pros and cons ?
    - the cathedral and the bazaar

Introducing versioning (continued)

Versioning

- **keeps track of [recorded] modifications** (so-called `commits`, rolling back)
- **allows for experimentations** (within so-called `branches`, ~ temporary copies)

Introducing versioning (continued)

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Together with a web hosting service (forge)

- **facilitates** team working

Introducing `git`

- three spaces to deal with :
  - your **working copy** of the project (obtained via either `git init` or `git clone`)
  - your **index** (space containing the current unrecorded modifications, located in `.git` subdir)
  - your **history** (space containing the code branches and versions, located in `.git` subdir)
- Each recorded modification is given an **identifier** (hash code)
- `HEAD` is the nickname of the last recorded modification

Introducing `git` (continued)

- Creating a new local project

  ```
  $ git init
  ```

- Getting information about local files

  ```
  $ git status
  ```

- Adding modifications to the index

  ```
  $ git add
  ```

- Recording modifications to the history

  ```
  $ git commit
  ```

Introducing `git` (continued)

- Creating a local clone of an existing project

  ```
  $ git clone <URL>
  ```

  (this existing project becomes the default *remote*)

- Pushing modifications to a remote

  ```
  $ git push [remote / branch]
  ```

- Pulling modifications from a remote

  ```
  $ git pull [remote / branch]
  ```

- Adding a remote (must have a common history!)

  ```
  $ git remote add <name> <URL>
  ```

Anatomy of git logs

```
git log
```

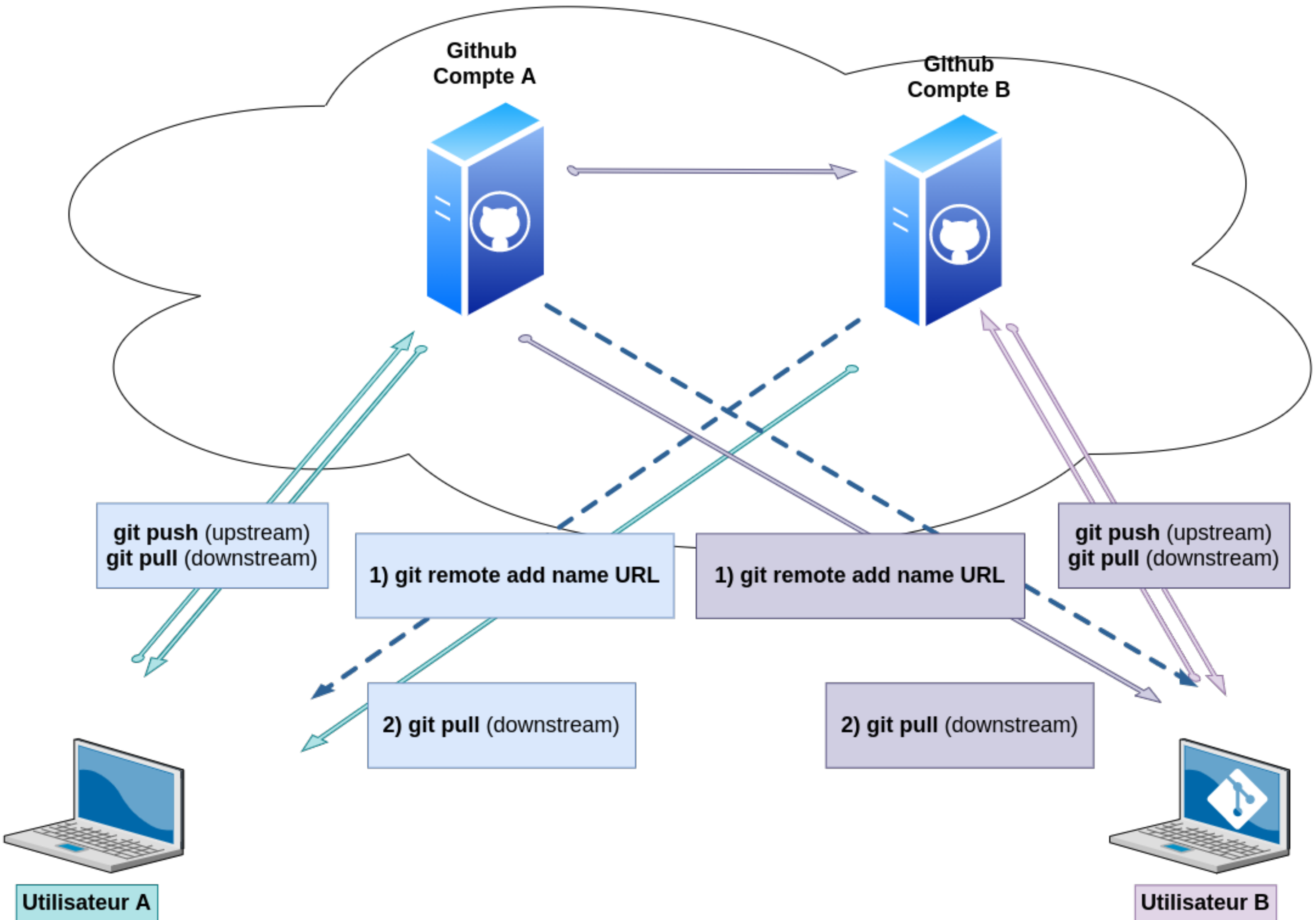
```
commit 2592da4330b4df6d482a631f4a35543b96f4744d
Merge: bff46dc 50b5135
Author: Alexander Matthes <ziz@mailbox.org>
Date:   Thu May 23 10:07:29 2019 +0200

    Merge branch 'master' of github.com:theZiz/aha

commit bff46dc3938df4699d92dc4a98cd57f8f2541448
Author: Alexander Matthes <ziz@mailbox.org>
Date:   Thu May 23 10:06:17 2019 +0200

    Added optional language attribute
```

Team work using `git`



git push (upstream)
git pull (downstream)

1) git remote add name URL

2) git pull (downstream)

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git push (upstream)
git pull (downstream)

For more information :

A visual Git Guide

Learn Git Branching

For future practical sessions

- **Get a copy of the notebook** used for the practical session (see the course on Arche/Moodle)

- **Run** you local notebook :

```
cd <where the notebook has been saved>
jupyter notebook
```

- Should you need to *locally* **keep track** of the versions of your work (global commands are invoked once on a given machine):

```
git config --global user.name "Your Name"
git config --global user.email "youremail@yourdomain.com"
git init .
git add <notebook_file>
git commit -m "<log message>"
```

Thank you!

Slideshow created using remark.

Exercise sheets (see the course on Arche/Moodle)

- Exercise sheet 1: Hands-on functional python
- Exercise sheet 2: Hands-on object-oriented python