Data Science and AI for Medicine Training School

TRAINING: Python Basics

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SACHSEN
Diese Maßnahme wird gefördert durch die Bundesregierung aufgrund eines Beschlusses des Deutschen Bundestages. Diese Maßnahme wird mitfinanziert durch Steuermittel auf der Grundlage des von den Abgeordneten des Sächsischen Landtags beschlossenen Haushaltes.

AGENDA

- Programming Concepts
- Python – Terms and Definitions
- Execution of Python Code
- Python – Virtual Environments
- *Python – Built-in types*
- *Python – Conditions*
- *Python – Loops*

Programming Concepts

What is programming?

- Use of programming language to implement software requirements as a computer program
- Computer program is converted into machine code for execution (compiled or interpreted)

What is a programming language?

- Tool for formulating algorithms and data structures
- Formal language with syntax and semantics

Algorithm

- Consists of instructions to solve a problem
- Instructions consist of permitted patterns

Data Structure

- Object to store and organize data in memory

Syntax

- Formal set of rules for the use of instructions
- "Grammar" of a programming language

Semantics

- Actual meaning of the instructions

What is Python?

Universal high-level programming language, also often used for scripting

- Released in 1994, recent stable version is 3.13
- Goals: simplicity, clarity, extensibility
  - Few reserved keywords, reduced syntax
  - Extensive standard library, e.g., file handling, math, text processing, …
  - Easy integration of additional packages / libraries
- Open Source, portable on multiple platforms
- Extensively used in data science, data analysis, artificial intelligence
- Easy management and use of additional packages and extensions
  - Built-in package manager “pip” with Python package index PyPI
  - Python distributions shipping Python + alternative package manager (e.g., “conda”) + virtual environments + preinstalled packages) – e.g., Miniconda, Anaconda

(TM) Trademark of the PSF
https://www.python.org

What is Python?
Terms and definitions

Variable
Container for storing assigned data in memory, using a name for reference

Object
Complex structure which bundles data and methods to operate on the data

Method
Block of code tied to an object, usable via dot-Operator ("**m**ethod is **m**ine")

Everything in Python is an object

Variable name

Assignment

Value of specific type

Definition of custom object

Instantiation and assignment to variable

Use of object's method

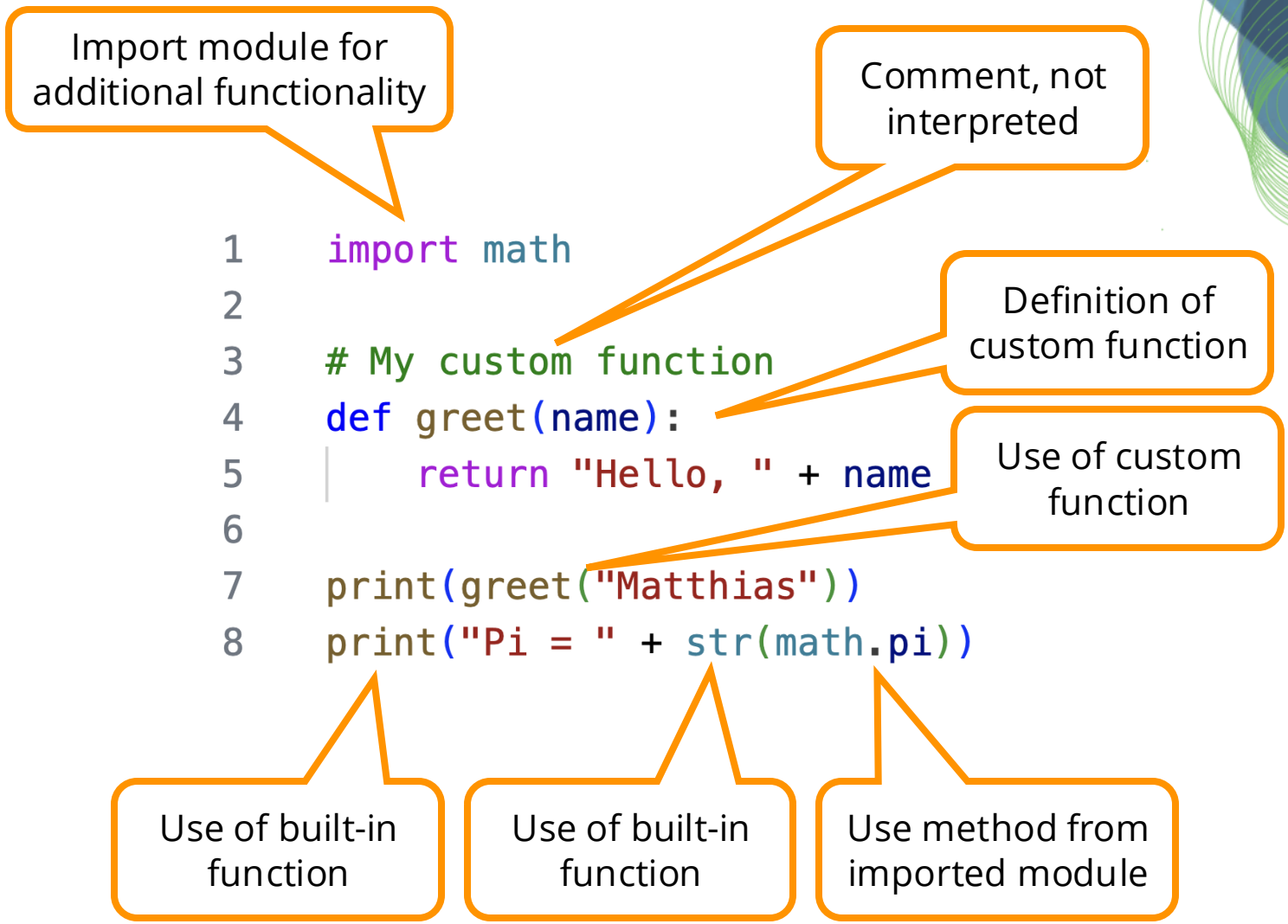
```
1   x = 5
2
3   class Human:
4       def __init__(self, name):
5           self.name = name
6
7       def say_hello(self):
8           return "Hello, I'm " + self.name
9
10  myself = Human("Matthias")
11
12  print(myself.say_hello())
```

What is Python?
Terms and definitions

Function
Independent block of reusable code for a specific task
("**f**unction is **f**ree")

Module
File containing Python code which can be imported into other Python code

Comment
Lines in code not interpreted by Python, used for documentation, starting with #



Execution of Python code

Execution via Python file

- Save code in file with file extension ".py"
- Execute file with installed Python

hello.py

```
1    print("hello world")
```

```
BIDS — -zsh — 42×5
matthias@MBP14M2 BIDS % python3 hello.py
hello world
matthias@MBP14M2 BIDS %
```

Interactive execution in terminal

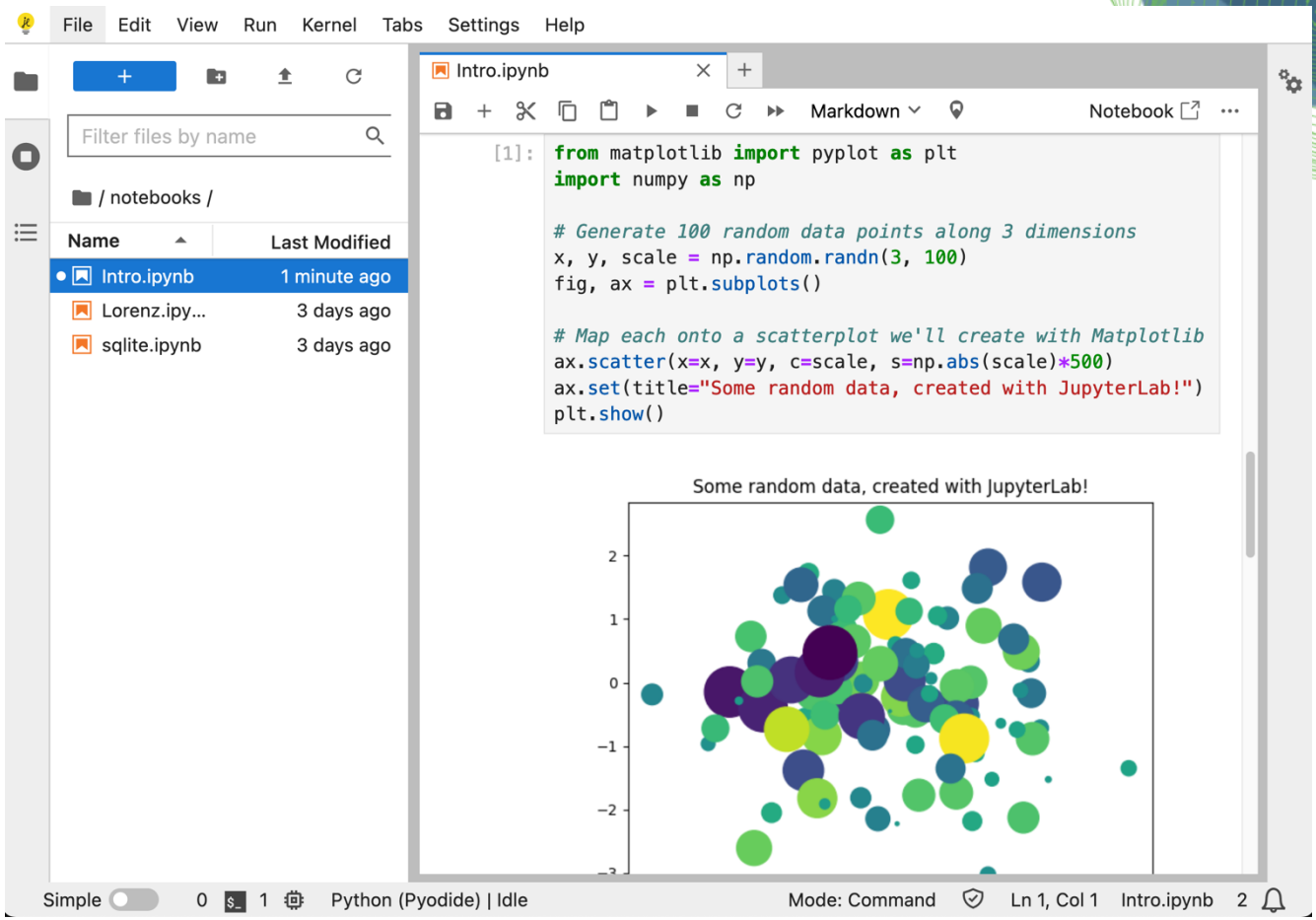
- Start interactive Python session
- Enter and execute instructions line by line

```
BIDS — -zsh — 58×10
matthias@MBP14M2 BIDS % python3
Python 3.12.2 (main, Feb  6 2024, 20:19:44) [Clang 15.0.0
(clang-1500.1.0.2.5)] on darwin
Type "help", "copyright", "credits" or "license" for more
information.
>>> x = 5
>>> print(x)
5
>>> exit()
matthias@MBP14M2 BIDS %
```

Execution of Python code

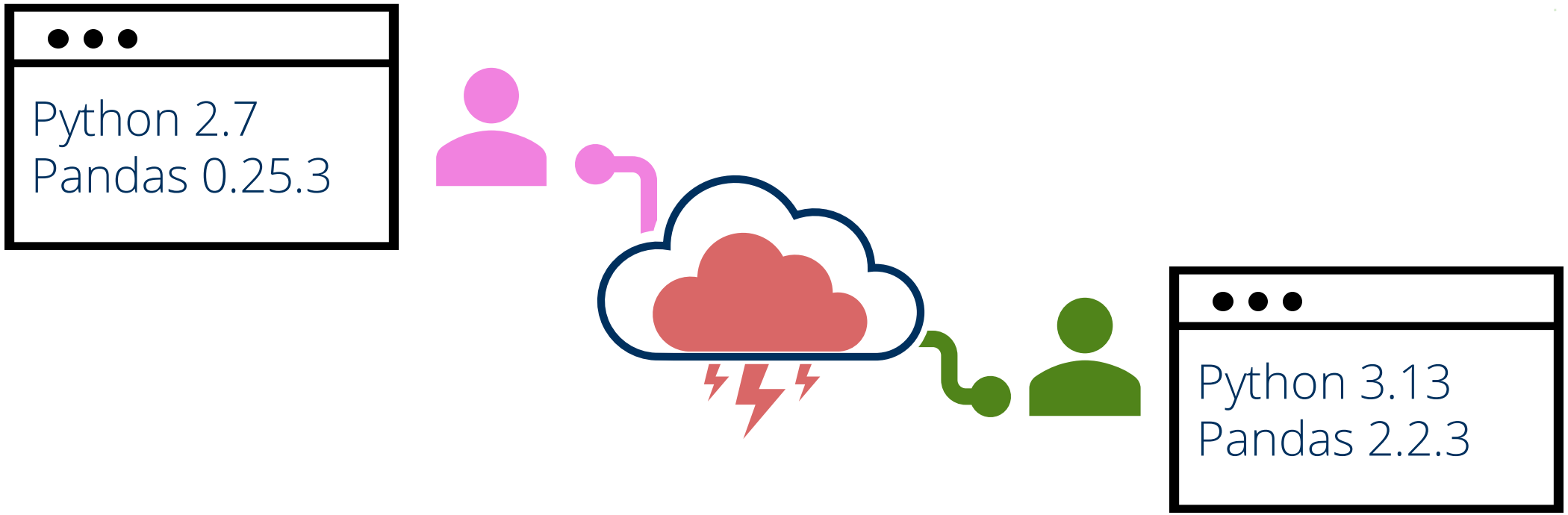
Interactive execution in Jupyter Notebook

- Web-based interface with cells for
  - Executable Python code
  - Rich text for documentation
  - Rich output for text, images, plots
- **Jupyter Lab** with
  - Jupyter notebook
  - File browser
  - Terminal access
  - Plugins

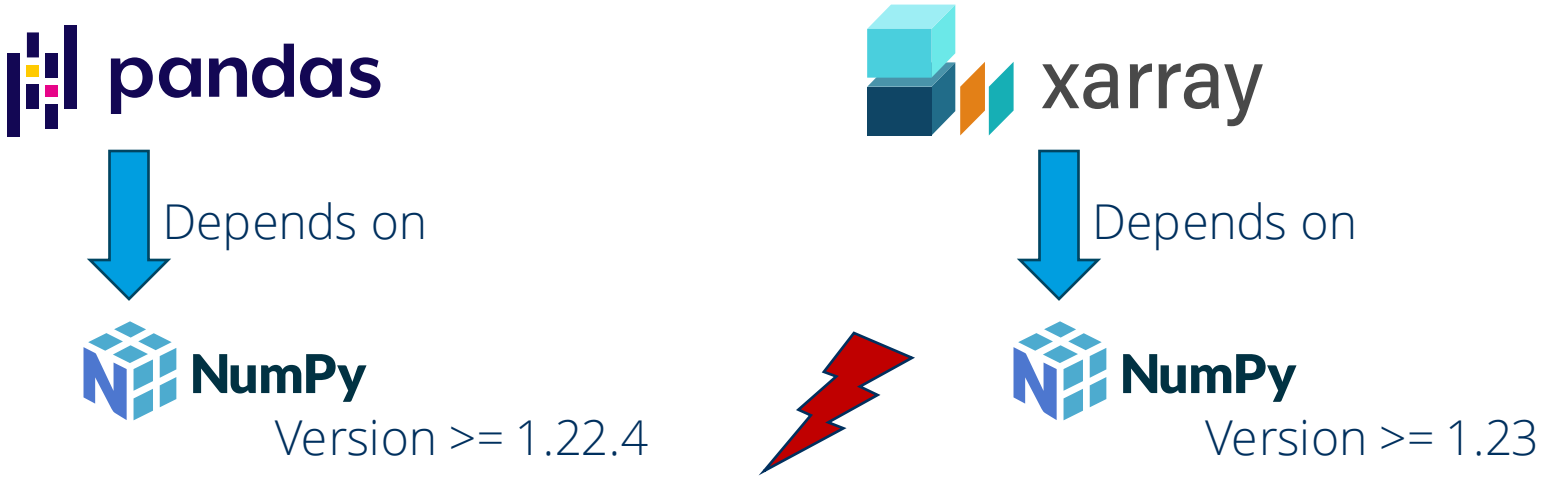


https://jupyter.org/try-jupyter/lab/index.html

Python – Virtual Environments



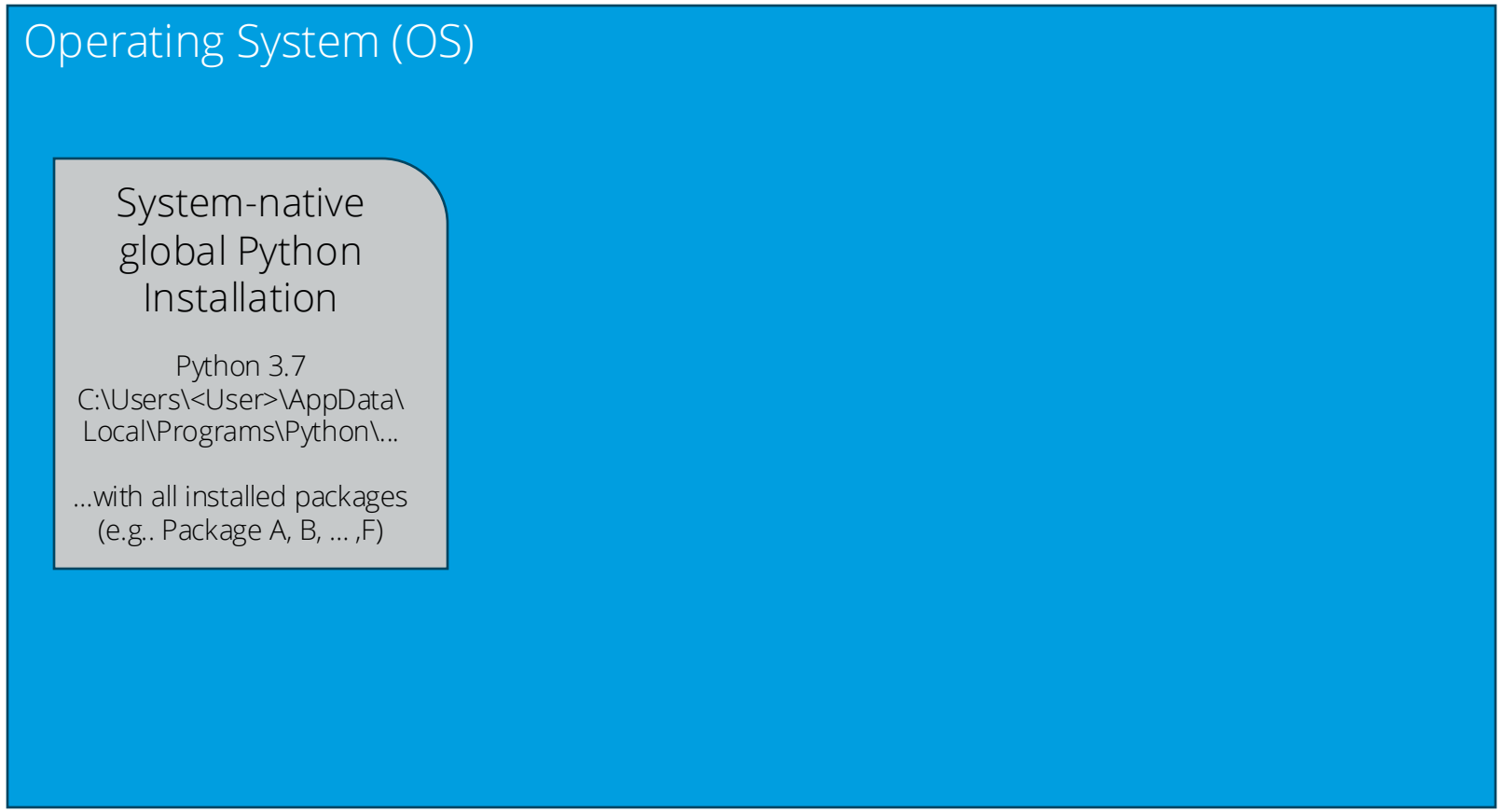
Python – Virtual Environments



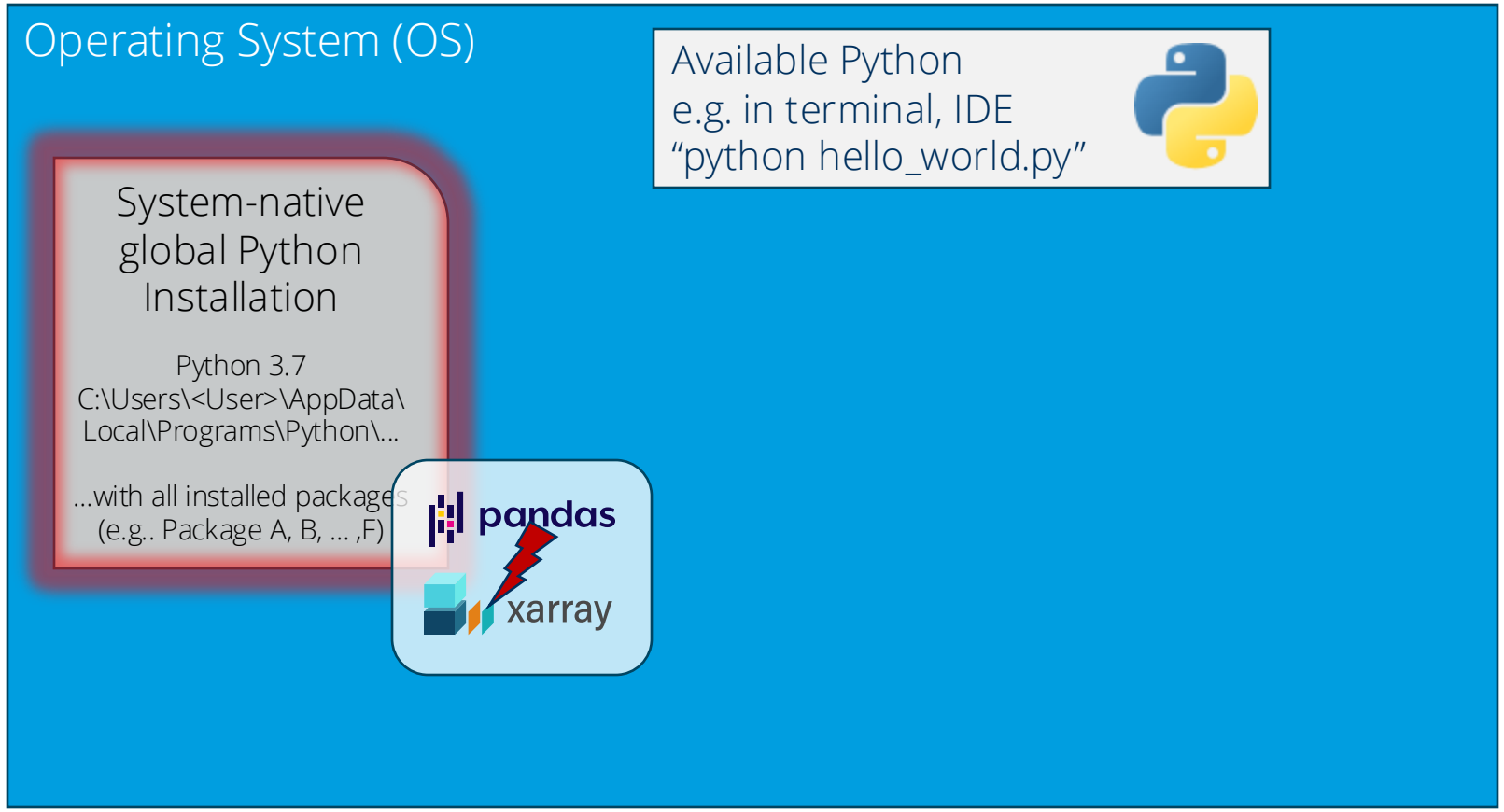
Dedicated environment for specific applications with according software and versions

- Isolation of dependencies: different projects require different software in different versions (…with dependencies in different versions)
- Reproducibility: configured environments can be saved and restored
- Stability: changes to one project/environment do not affect others
- Collaboration: everyone in the project uses the same environment, same software, same versions

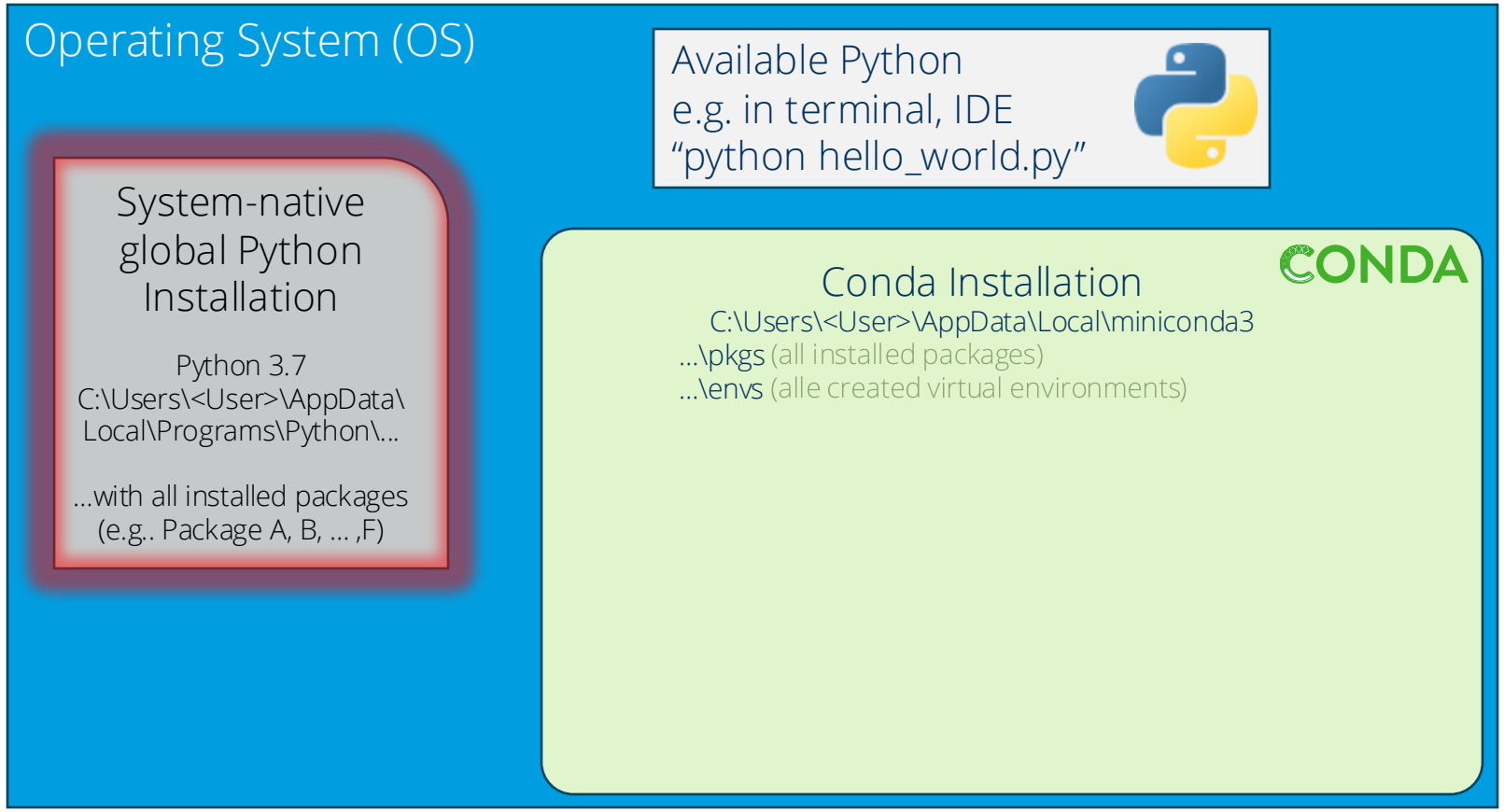
Python – Virtual Environments



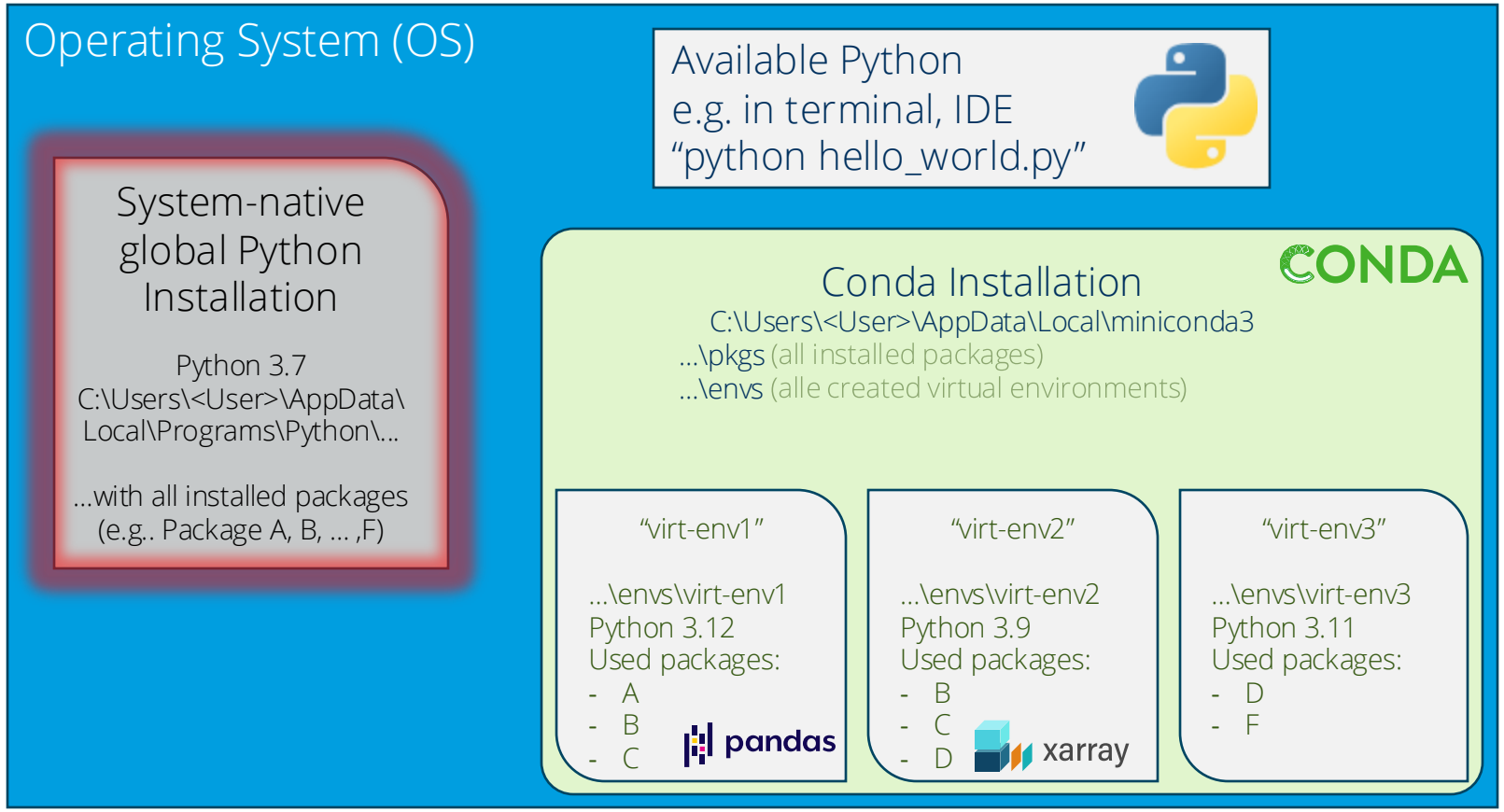
Python – Virtual Environments



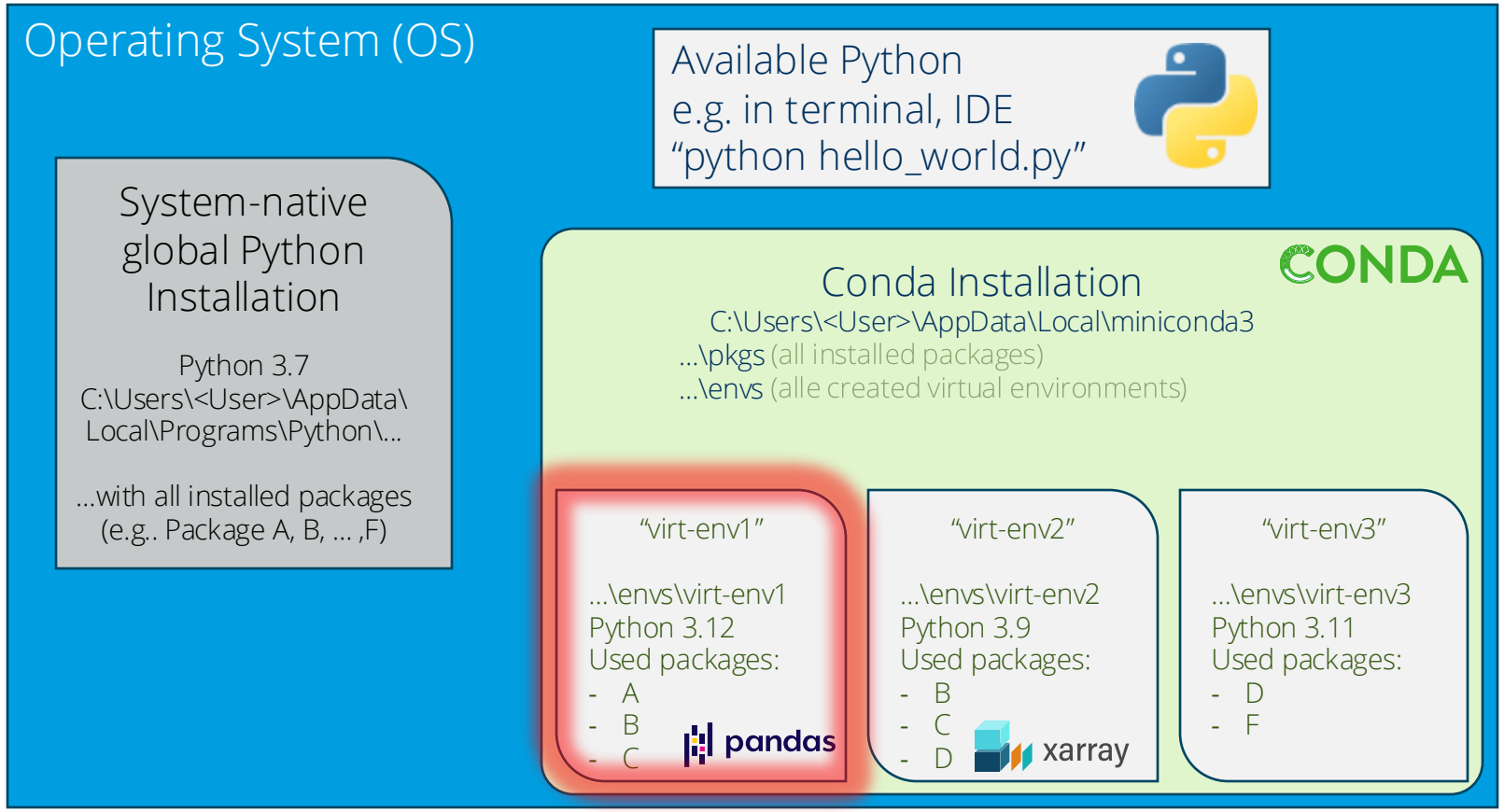
Python – Virtual Environments



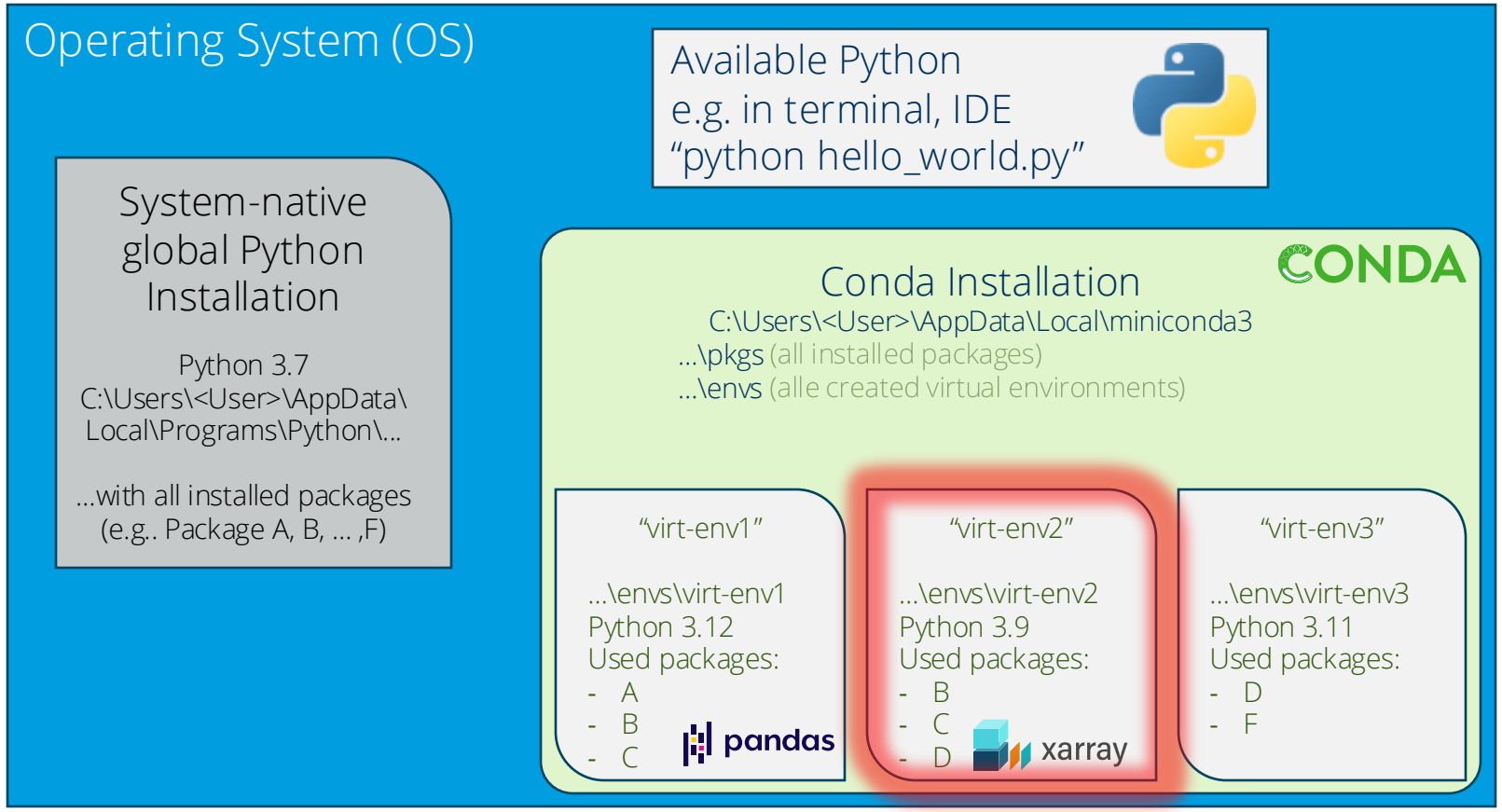
Python – Virtual Environments



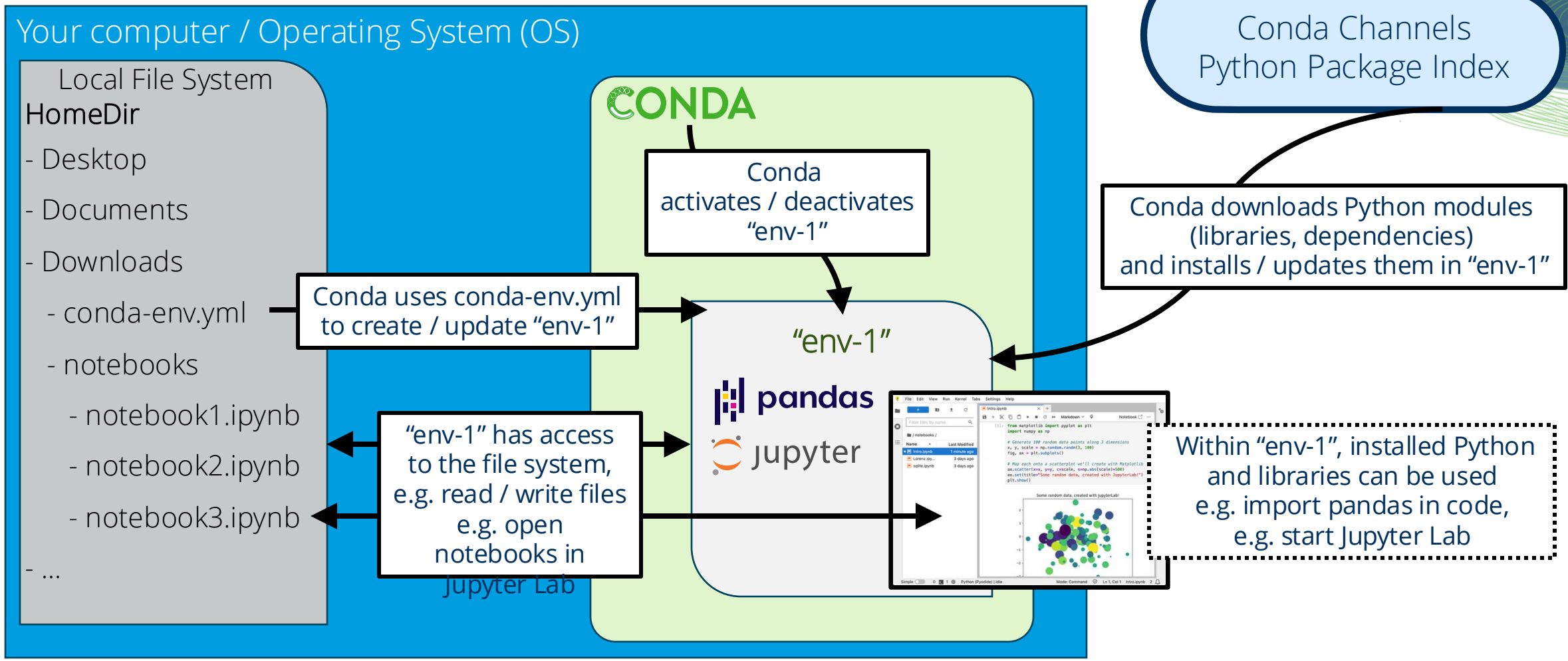
Python – Virtual Environments



Python – Virtual Environments



Python – Virtual Environments
Interactions with your computer and the internet



Python - Built-in types
Truth and Boolean

Truth value and Boolean

- Objects can be tested for a truth value
- Truth values can be used **in conditions**
- Represented by Booleans: `True` (1) and `False` (0)
- There are default truth values for objects,
  e.g., number zero or empty strings are considered `False`

Boolean operators and comparisons

- Used to evaluate a truth value
- Operators are `and`, `or`, `not`
- Comparisons are, e.g., < (strictly less), == (equal),
  >= (greater than or equal), `!=` (not equal)

```
1 # Boolean operators
2 print(True and False)
3 print(True or False)
4 print(not True)
```

Executed at 2024.05.05 09:52:32 in 4ms

```
False
True
False
```

```
1 # Comparisons
2 print(True == False)
3 print(True != False)
4 print(True > False) # But why?
```

Executed at 2024.05.05 09:52:32 in 2ms

```
False
True
True
```

```
1 # Math with Boolean
2 print(int(True), int(False))
3 print(True + True)
```

Executed at 2024.05.05 09:52:32 in 1ms

```
1 0
2
```

Python - Built-in types
Numeric types

Numeric types

- Integers (`int`)
- Floating point numbers (`float`)
- Complex numbers (`complex`)

Supported operations

- Mathematical operators, e.g., +, -, /
- Comparisons
- Mathematical functions

```
1  # Numerical types
2  print(type(5))
3  print(type(1.5))
4  print(type(2j))
```

Executed at 2024.05.05 10:16:36 in 4ms

```
<class 'int'>
<class 'float'>
<class 'complex'>
```

```
1  # Comparisons
2  print(5 > 1)
3  print(5 == 1)
```

Executed at 2024.05.05 10:16:36 in 1ms

```
True
False
```

```
1  # Operators
2  print(5 + 5)
3  print(5 * 5)
4  print(5 / 5)
```

Executed at 2024.05.05 10:16:36 in 1ms

```
10
25
1.0
```

```
1  # Mathematical functions
2  print(abs(-5))
3  print(pow(5, 2))
4  print(round(4.5))
```

Executed at 2024.05.05 10:16:36 in 1ms

```
5
25
4
```

Some may behave unexpected!

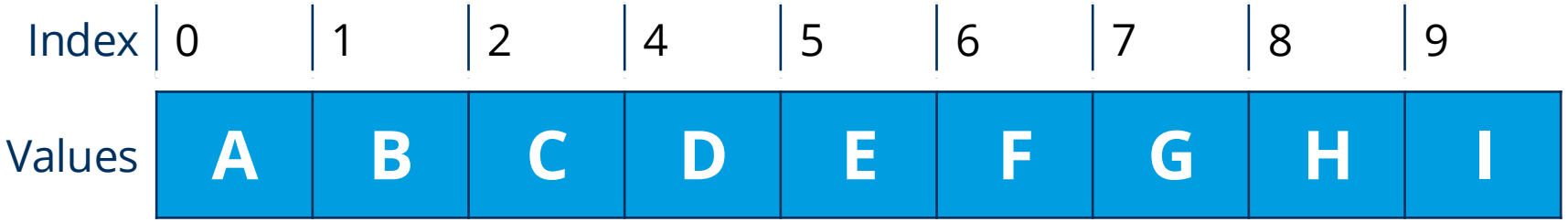
Python - Built-in types
Sequence types

Some basics on sequences

- Data structures to store and manipulate multiple values
- Values can be of homogeneous or heterogeneous type
- Sequences are either mutable (values can be changed “in place”) or immutable
- Values can be accessed by an index on the sequence, starting at 0

```
1  my_list = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I']
```

Executed at 2024.05.05 10:42:01 in 3ms



Python - Built-in types
Sequence types

Lists

- *Mutable*, construction via brackets [ ]
- Homogenous or heterogenous values

```
# Define a list
my_list = ['A', 'B', 'C', 'D', 'E', 'F']
print(type(my_list))
print(my_list)
```
Executed at 2024.05.05 10:57:22 in 5ms

```
<class 'list'>
['A', 'B', 'C', 'D', 'E', 'F']
```

```
# Access separate elements
# Called "indexing"
print(my_list[0])
print(my_list[-1])
```
Executed at 2024.05.05 10:57:22 in 2ms

```
A
F
```

Use negative index to start at the last element

Get elements from index 1 to 2

Get every second element, start at index 2

```
# Access subsets of elements
# Called "slicing"
print(my_list[1:3])
print(my_list[:4])
print(my_list[2:])
print(my_list[2::2])
```
Executed at 2024.05.05 10:59:07 in 3ms

```
['B', 'C']
['A', 'B', 'C', 'D']
['C', 'D', 'E', 'F']
['C', 'E']
```

Get all elements up to index 3

Get all elements starting at index 2

```
# Built-in methods
my_list.reverse()
print(my_list)
my_list.sort()
print(my_list)
```
Executed at 2024.05.05 11:13:18 in 3ms

```
['F', 'E', 'D', 'C', 'B', 'A']
['A', 'B', 'C', 'D', 'E', 'F']
```

Call built-in method to reverse the list

Python - Built-in types
Sequence types

Tuples

- *Immutable*, construction via parentheses ( )
- Homogenous or heterogenous values
- Indexing and slicing works like for lists

```
1  # Define a tuple
2  my_tuple = ('A', 1)
3  print(type(my_tuple))
4  print(my_tuple)
5  print(my_tuple[0])
6  # Immutable!
7  my_tuple[0] = 'B'
```

Executed at 2024.05.05 12:24:07 in 32ms

```
<class 'tuple'>
('A', 1)
A
Traceback…
TypeError: 'tuple' object does not support item assignment
```

Ranges

- *Immutable*, construction via `range( )`
- Homogenous numerical values
- Indexing and slicing works like for lists

```
1  # Define a range
2  my_range = range(10)
3  print(type(my_range))
4  print(my_range)
5  print(my_range[-1])
6  # Convert to list
7  print(list(my_range))
```

Executed at 2024.05.05 12:24:53 in 4ms

```
<class 'range'>
range(0, 10)
9
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

Python - Built-in types
Sequence types

Text sequence - string

- *Immutable*, construction via quotes " ", ' '
- Values of type Unicode codepoints
- Indexing and slicing works like for lists

```
# Define a string
my_string = 'Hello World!'
print(type(my_string))
print(my_string)
```

Executed at 2024.05.05 12:30:56 in 3ms

```
<class 'str'>
Hello World!
```

```
# Indexing and slicing
print(my_string[0])
print(my_string[6:])
```

Executed at 2024.05.05 12:31:02 in 3ms

```
H
World!
```

```
# Built-in methods
print(my_string.upper())
print(my_string.split(' '))
```

Executed at 2024.05.05 12:32:39 in 4ms

```
HELLO WORLD!
['Hello', 'World!']
```

Convert all letters to uppercase

Split the string at whitespace and return a list of resulting strings

Python - Built-in types
Sequence types

Further operations on sequences

- Sequences can be concatenated (append them) with + operator
- Sequences can be tested for their content with `in`

```
# Concatenate strings
hello = 'Hello'
world = 'World'
full = hello + ' ' + world
print(type(full))
print(full)
```

Executed at 2024.05.05 12:49:04 in 4ms

```
<class 'str'>
Hello World
```

```
# Concatenate lists
list_1 = [1, 2, 3]
list_2 = ['A', 'B', 'C']
list_3 = list_1 + list_2
print(type(list_3))
print(list_3)
```

Executed at 2024.05.05 12:49:14 in 3ms

```
<class 'list'>
[1, 2, 3, 'A', 'B', 'C']
```

```
# Test for specific values
print('A' in list_3)
print(10 in list_3)
```

Executed at 2024.05.05 12:50:50 in 3ms

```
True
False
```

Python - Built-in types
Dictionaries

Mapping types or dictionaries (dicts)

- *Mutable*, construction via braces { }
- Provide a mapping from `key` → `value`, `i.e.` a list of `key` → `value` pairs
- Indexing and slicing works NOT like for lists

```
1  # Define a dict
2  german_english_dict = {
3      'Vorlesung': 'Lecture',
4      'Gleichung': 'Equation'
5  }
6  print(type(german_english_dict))
7  print(german_english_dict)
```

Executed at 2024.05.05 13:12:17 in 3ms

```
<class 'dict'>
{'Vorlesung': 'Lecture', 'Gleichung': 'Equation'}
```

```
1  # Access values by their keys
2  print(german_english_dict['Vorlesung'])
3  print(german_english_dict['Unknown'])
```

Executed at 2024.05.05 13:13:26 in 13ms

```
Lecture
Traceback…
KeyError: 'Unknown'
```

```
1  # Modify the values
2  german_english_dict['Vorlesung'] = 'Course'
3  # Add new entries
4  german_english_dict['Eintrag'] = 'Entry'
5  print(german_english_dict)
```

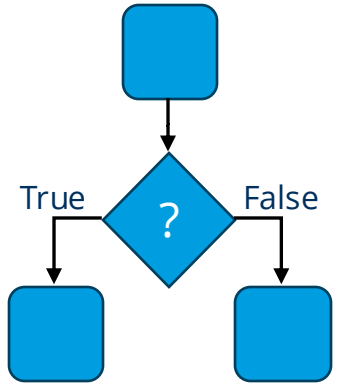
Executed at 2024.05.05 13:15:09 in 2ms

```
{'Vorlesung': 'Course', 'Gleichung': 'Equation',
 'Eintrag': 'Entry'}
```

Python - Conditions

Conditional statements

- Used as control flow tool, e.g., to check
  - if pre-requisites are met
  - if data has the right format or value
  - if there are any errors
- The `if` statement is used to
  - Evaluate a Truth value for given expressions, e.g., with Boolean operators of comparisons
  - Executes subsequent code if the Truth value evaluates to `True`
- The `else` statement can be used to execute code if the given expressions evaluate to `False`




```
# Preceding code
# Defines and works on my_list

# Check condition
if 'Z' in my_list:
    # Do this if the condition is True
    print('Z is in my_list!')
else:
    # Do this if the condition is False
    print('Z is not in my_list!')

# Subsequent code
```

Executed at 2024.05.05 13:41:29 in 3ms

```
Z is not in my_list!
```

Python - Loops

Loop statements

- Used as control flow tool for repeated execution of code
- Different kinds of loop statements
  - `for`: iterates over elements of a sequence (e.g. list), or iterable objects in general
  - `while`: repeats subsequent code as long an expression is `True`
- Both can be controlled in more detail using
  - `break` to terminate the loop
  - `continue` to skip the current iteration

```python
my_list = ['A', 'B', 'C', 'D', 'E', 'F']
# Use for to iterate over my_list
for i in my_list:
    # Skip iterations for letters between B and E
    if 'B' < i < 'E':
        continue
    print(i)
```

Executed at 2024.05.05 14:25:27 in 3ms

```
A
B
E
F
```

```python
i = 10
# Use while to decrement number till 0
while i >= 0:
    i = i - 1
    # Stop loop if number hits criteria
    if i % 5 == 0:
        break
    print(i)
```

Executed at 2024.05.05 14:31:33 in 3ms

```
9
8
7
6
```

Any questions or remarks?

Let’s practice – Python Basics in Jupyter Lab