Lecture 2: Functions, Files, Collections, and Git

MPCS 51042-1 : Python Programming

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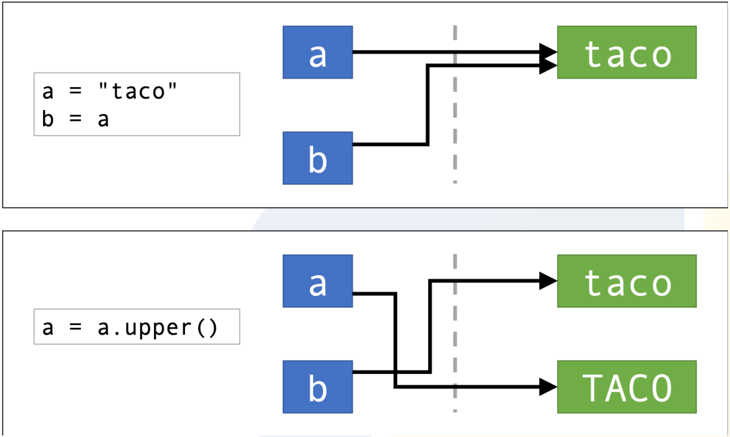
Shared References to Immutable Objects

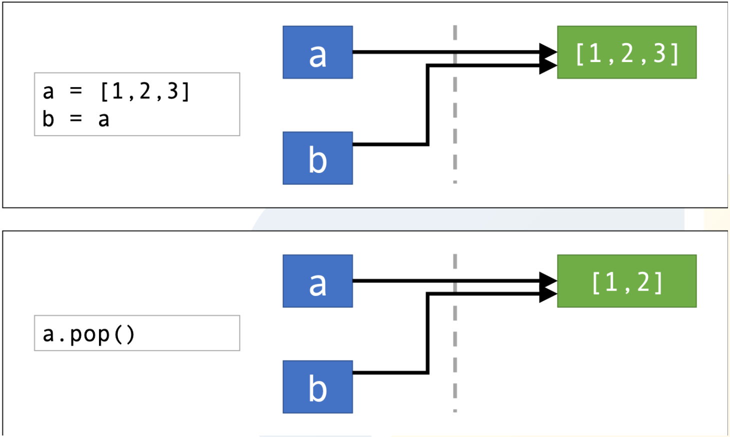


```
a = "taco"
b = a
```

```
a = a.upper()
```

- `a.upper()` creates a new string object. The name `a` now points to the new object.
- The name `b` still points to the original object.

Shared References to Mutable Objects



```
a = [1,2,3]
b = a
```

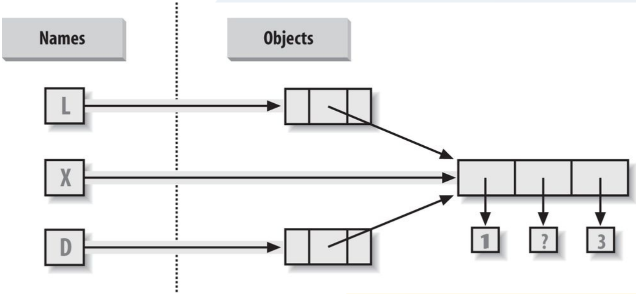
```
a.pop()
```

- a.pop() modifies the list object in-place. The name a still points to this object.
- The name b still points to the original object.

Shared References Inside Collections

These collections have shared references to the same list object.

```
X = [1, 2, 3]
L = ['a', X, 'b']
D = {'x':X, 'y':2}
```



What happens when we set `X[1] = 'surprise'`?

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A First Example

```python
def intersect(seq1, seq2):
    res = []
    for x in seq1:
        if x in seq2:
            res.append(x)
    return res
```

- The function is not defined until the `def` statement is executed.
- When the `def` statement is executed, a new function object is created and bound to the name of the function.
- Arguments from caller are assigned to local variables.
- Variables defined inside function are also local.
- Returning a local variable removes the variable but keeps the object.

Thinking About Polymorphism

```python
def intersect(collect1, collect2):
    res = []
    for x in collect1:
        if x in collect2:
            res.append(x)
    return res
```

- Parameters types are not declared or checked.
- Type-checking could prevent future objects from working with this.
- In Python, we code for object interfaces, not object types.

Arguments and Shared References

In-place changes to shared objects can affect the caller.

```python
def changer(a, b):
    a = 2       # Changes local variables name
    b[0] = 2    # Changes shared object in-place


X = 1
L = ['a', 'b']
changer(X, L)  # L will be affected
```

Argument Matching from the Caller's Perspective

Given any function, the caller has several ways to match its arguments

- `func(value)` : Match argument by position
- `func(name=value)` : Match argument by keyword
- `func(*iterable)` : Unpack an iterable into positional arguments
- `func(**dict)` : Unpack a dict's key/value pairs into keyword args

These argument matching modes can be mixed, but must follow this order:

- Positional arguments
- Any combination of keyword and `*iter` args
- `**dict` args

Argument Matching in Function Definition

A function can define how its arguments are assigned to locals:

- `def f(name)` : Matched by position or keyword
- `def f(name=default)` : If not matched, define local to `default`
- `def f(*name)` : Matches and collects remaining positional arguments in tuple.
- `def f(**name)` : Matches and collects remaining keyword arguments in a dict.

These argument matching modes can be mixed, but must follow this order:

- Normal arguments
- Default arguments
- `*name` arguments
- `**dict` arguments

Argument Packing and Unpacking in Action

```python
def mymin(first, *rest):
    for arg in rest:
        if arg < first:
            first = arg
    return first
```

Many ways to call this!

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Files

- A file object is instantiated by the `open()` built-in function
- The object's methods allow you to read/write strings .
- Useful methods include:
  - `f = open(filename, mode)` : Open a file and create a file object.
  - `s = f.read()` : Read the whole file into one string.
  - `s = f.readline()` : Read a single line in a file as a string.
  - `L = f.readlines()` : Read all lines into a list of strings.
  - `f.write(s)` : Write one string to a file.
  - `f.writelines(s)` : Write strings in a list to lines in a file.
  - `f.close()` : Close the file
- Can also pass an open file object to `print()`

File Modes

In `open(filename, mode)`, the mode is a string that specifies whether the file is read-only, write-only, etc.

- `r` : read-only
- `w` : write-only
- `a` : append
- `r+` : read-and-write

Files as Iterables and in Context Managers

When used as an iterator, file objects will return one line at a time:

```
f = open('myfile.txt', 'r'):
for line in f:
    # do something with line
f.close()
```

In a context manager, the file will be open and closed automatically:

```
with open('myfile.txt', 'r') as f:
    for line in f:
        # do something with line
```

File Examples

For these examples, use the "mpg" dataset from the seaborn packages (see `https://github.com/mwaskom/seaborn-data/blob/master/mpg.csv` and `http://archive.ics.uci.edu/ml/datasets/Auto+MPG`)

- Parse the .csv such that:
  - The header is in a list
  - The data are in a nested list
- Output the "name", "year", "weight", and "mpg" columns into a new file.

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Dictionaries

Dictionaries are a mutable mapping type which associates keys with values

- The key must be a hashable type (integers, strings, tuples, etc.)
- The value is a reference and can refer to any object type.
- Keys are stored in a hash table for fast lookup. A particular ordering cannot be assumed.

Lots of ways to instantiate lists:

```
d = {'name': 'Harry', 'age': 3}      # {key1: val1, ...}

d = dict(name='Harry', age=3)        # dict(key1=val1, ...)

# dict(((key1,val1), (key2, val2), ...)
d = dict((('name', 'Harry'), ('age', 3)))

# dict(zip(key_list, val_list))
d = dict(zip(('name', 'age'), ('Harry', 3)))
```

Dictionary Operations

Dictionaries support operations of collection types but not sequences:

- d[k] returns an item. Raises KeyError if k is not in d.
- d[k] = v sets an item. If k is in d, the current value is replaced. If k is not in d, the new key:value pair is added to the dict.
- k in d returns True if the keys contain k.
- len(d) returns the number of keys

```
d = {}                  # An empty list
d['name'] = 'Harry'     # Now d is {'name': 'Harry'}
print(d['age'])         # This raises `KeyError`
'name' in d             # True
'Harry' in d            # False
```

Dictionary Views

In Python 3, several dict methods return views. Views are iterables that:

- Reflect future changes to the dictionary.
- Support set operations such as union and intersection.
- Are immutable.

The following methods return views:

- `d.items()`: A view of the dict's `(key, value)` pairs.
- `d.keys()`: A view of the dict's keys.
- `d.values()`: A view of the dict's values.

When used as an iterator, a dictionary object itself also returns an iterable over the keys:

```python
for key in d:
    print(key)
```

Getting Dict Items

Methods for getting items:

- `d.get(key[,default])`: If `key` is in dict, return its value. If not, return `default` if given or `None` if not given.
- `d.pop(key[,default])`: If `key` is in dict, return and remove its value. If not, return `default` if given or raise `KeyError` if not given.
- `d.popitem()`: v3.6 and before: remove and returns an arbitrary `(key, value)` pair. v3.7: remove a `(key, value)` pair in LIFO order.
- `d.copy()`: Retun a shallow copy of `d` Reference: `https://docs.python.org/3/library/stdtypes.html#mapping-types-dict`

Setting Dict Items

Methods for setting items:

- `d.setdefault(key[, default])`: If `key` is in dict, return its value. If not, add the `(key, default)` pair and return `default`.
- `d1.update(d2)`: Add the keys/value from `d2` to `d1`. Overwrites existing keys in `d1`.

The `collections.defaultdict` object provides similar functionality to `d.setdefault` but can be more convenient.

- `https://docs.python.org/3/library/stdtypes.html#mapping-types-dict`
- `https://docs.python.org/3.7/library/collections.html#collections.defaultdict`

Dict Examples

For these examples, use the "mpg" dataset from the seaborn packages (see `https://github.com/mwaskom/seaborn-data/blob/master/mpg.csv` and `http://archive.ics.uci.edu/ml/datasets/Auto+MPG`)

- Parse the .csv such that the entire table is a dict. The keys are column names and the values are a list of entries.
- Output the "name", "year", "weight", and "mpg" columns into a new file.

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Sets

- Sets are unordered collections of unique, immutable, hashable objects.
- Sets may be instantiated by:
  - Literals: `s = {1, 2, 'a'}`
  - Function, using any iterable: `s = set([1, 2, 'a'])`
- Set operators accept only set objects:
  - Union: `s1 | s2`
  - Intersection: `s1 & s2`
  - Difference: `s1 - s2`
  - Symmetric difference: `s1 ^ s2`
  - Is subset: `s1 <= s2`
  - Is superset: `s1 >= s2`
  - etc.
- The corresponding set instance methods take any iterables:
  - `union()`, `intersection()`, `difference()`, `symmetric_difference()`, `issubset()`, `issuperset()`, etc.
- Reference: `https://docs.python.org/3/library/stdtypes.html#set-types-set-frozenset`

Set Demos

For these examples, consider the tests of “Frankenstein” and “Paradise Lost” from Project Gutenberg (`https://www.gutenberg.org/ebooks/84` and `https://www.gutenberg.org/ebooks/26`)

- Create sets of words from each text
- Compare the intersections of words from each text

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Tuples

- Tuples are immutable, ordered collections of references.
  - After instantiated, their length is fixed.
  - Cannot be modified in-place.
- Sequence operations apply (indexing, slicing, concat).
- May be instantiated by:

```
t = ()               # An empty tuple
t = (1,)             # A single-element tuple
t = (1, 'a', [2, 3]) # Heterogenous, nested
t = 1, 'a', [2,3]    # Same as above
t = tuple(iterbl)    # From an iterable
```

- Immutability only applies to the reference, not the object itself.
  - E.g., this nested list is still mutable: `t=(1,'a',[2, 3])`
- Reference: https://docs.python.org/3/library/stdtypes.html#tuple

Frame Title

For these examples, use the “mpg” dataset from the seaborn packages (see `https://github.com/mwaskom/seaborn-data/blob/master/mpg.csv` and `http://archive.ics.uci.edu/ml/datasets/Auto+MPG`)

- Parse the .csv into the following data structure:
  - The table is a dict. Each key is the (model, year) of a car. The corresponding value is a list of the other data
- Parse the .csv into the following data structure:
  - The table is a dict. Each key is the (model, year) of a car. The corresponding value is another dict where the key is a field name; and the values are the value for that (model, year).

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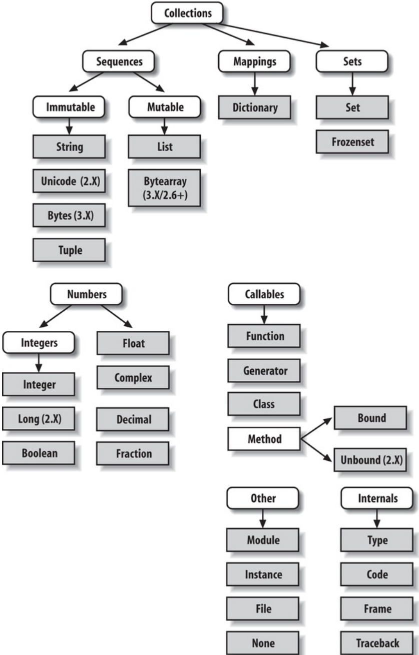
The Object Heirarchy: Everything is an object!



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What are doctests?

- Doctests concisely provide both documentation and executable tests.
- Part of standard library: `https://docs.python.org/3.7/library/doctest.html`
- Compatable with many 3rd-party testing frameworks (pytest, nose)
- Can't deal with very complicated, multi-stage use cases. Need to use other frameworks, like unittest (`https://docs.python.org/3.7/library/unittest.html`)

Writing Doctests

- Written as a multiline string that shows an interactive Python session.
- Statements are run and compared to output.
- To pass, the output must match exactly.

The top of: out_of_class_demos/intersect.py

```
"""
>>> intersect([1, 2, 4], [6, 4, 2])
[2, 4]
>>> intersect([1, 2, 4], [4, 8, 2, 6])
[2, 4]
>>> intersect([1, 3, 5], [2, 4, 6])
[]
>>> intersect([1, 2, 4], [])
[]
>>> intersect("apple", "aerofoil")
['a', 'l', 'e']
"""
```

Running Doctests

- Can run on command line. Default usage only shows failed tests.

```
$ python3 -m doctest intersect.py
```

- Use the -v flag to show both passed and failed tests.

```
$ python3 -m doctest -v intersect.py
```

- Can run inside larger testing frameworks
- Can run inside PyCharm (maybe other IDEs?)

Choosing Tests

- Your program is only as good as its tests!
- Let's add this test and see what happens:

```
"""
>>> intersect('apple', 'pear')
['a', 'p', 'e']
"""
```

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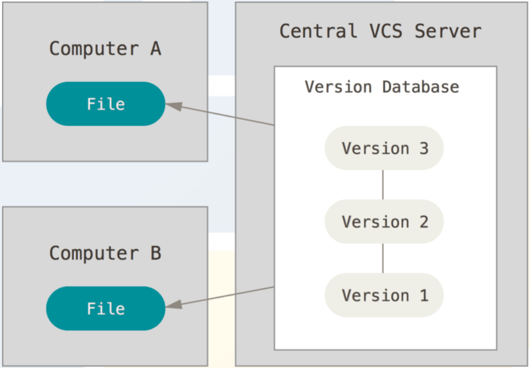
What is version control?

- A version control system (VCS) records changes to a set of files
  - All the recorded changes are called the history
  - The VCS can retrieve specific, previous versions of files
- Advantages of using VCS
  - If a bug is discovered after you deploy, you can revert to a working version
  - Can help discover which specific change caused the bug
  - Can discover which developer was responsible for that change

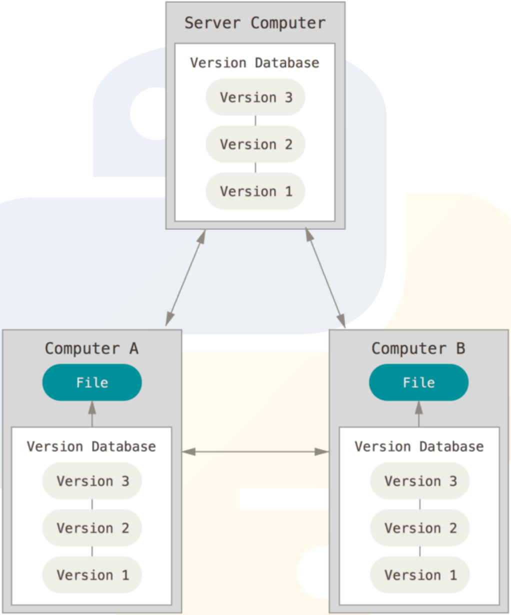
SVN etc.: Centralized VCS

- **Pros:** Individual devs can see everyone's activity. Admin has fine-grained control over database permissions.
- **Cons:** Single point of failure. Devs can't update database if their connection is offline.



Git: Distributed VCS

- Everyone has entire database:
  - Arbitrarily-many remote servers
  - Arbitrarily-many local clients
- **Pros:** Any server or client can used to recover the database. Clients can work offline. New non-linear workflows are possible.
- **Cons:** Learning curve.

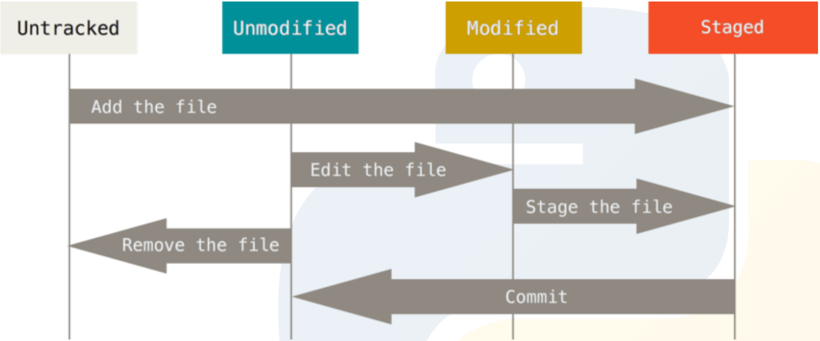


Areas in Your Local Project

```
drwxr-xr-x  12 rahaman  staff  384 Oct 10 18:02 .git
-rw-r--r--   1 rahaman  staff   88 Oct 10 18:02 .gitlab-ci.yml
-rw-r--r--   1 rahaman  staff  117 Oct 10 18:02 README.md
drwxr-xr-x   3 rahaman  staff   96 Oct 10 18:05 __pycache__
-rw-r--r--   1 rahaman  staff  637 Oct 10 18:03 my_abs.py
```

- **The Working Tree:** The files you're currently working on (my_abs.py, README.md, .gitlab-ci.yml)
- **The Git Directory:** The local database (.git)
- **The Staging Area (or Index):** Files are put here before updating the local database (not shown)

Lifecycle of Files



- Untracked: Not in local database
- Tracked: Some version in local database
  - Unmodified (or committed): Up-to-date with local database
  - Modified: File is changed in working
  - Staged: File's changes will go in next local database update

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Getting and Setting-up Git

- Many choices of clients
  - We'll cover the command line tool (`https://git-scm.com/downloads`).
  - Many GUI clients are available (`https://git-scm.com/downloads/guis`).
  - Many IDEs have integrated clients (`https://www.jetbrains.com/help/pycharm/using-git-integration.html`)
- Pro Git Ch 1.6 describes first-time setup of command-line client (`https://git-scm.com/book/en/v2/Getting-Started-First-Time-Git-Setup`)
  - Username and user email can be your CNET ID and @uchicago.edu email.
  - Editor can be anything
- To use UChicago's GitLab, you should set up an SSH key: `https://mit.cs.uchicago.edu/help/ssh/README.md`

Creating or Downloading Project

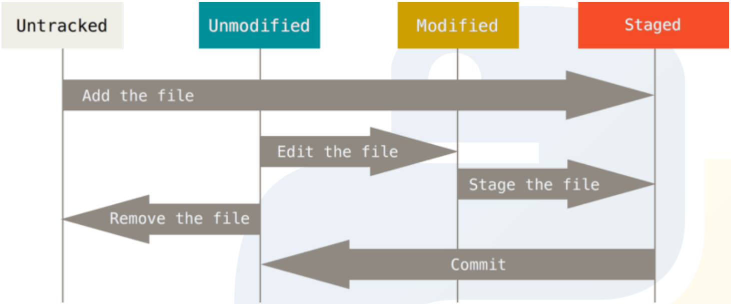
- We'll work with two demo repos in this lecture:
  - We'll be looking at this small pre-completed demo project: `https://mit.cs.uchicago.edu/mpcs51042-aut-19/git-demo-1`
  - We'll be developing this repo from scratch: `https://mit.cs.uchicago.edu/mpcs51042-aut-19/git-demo-2/`
- `git clone`: Download an existing repo

```
$ git clone git@mit.cs.uchicago.edu:mpcs51042-aut-19/git-demo-1.git
$ cd git-demo-1/
```

- `git init`: Create a new repo in the current directory

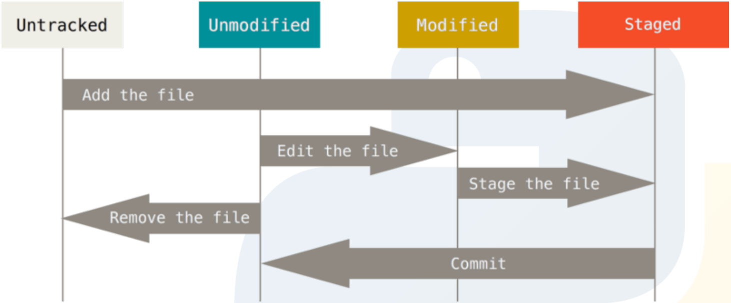
```
$ mkdir git-demo-2
$ cd git-demo-2/
$ git init
```

Adding Local Changes



- For new files:
  - **Untracked** → **Staged:** `git add <file>`
- For existing files:
  - **Unmodified** → **Modified:** Any text editor, IDE
  - **Modifed** → **Staged:** `git add <file>`
  - **Staged** → **Unmodified:** `git commit`

Undoing Local Changes



- **Staged → Modified:** `git reset -- <file>`
- **Modified → Unmodified:**
  - Lose changes forever: `git checkout -- <file>`
  - Keep changes for later: `git stash`
  - Apply stashed changes: `git stash apply`
- **Unmodified → Untracked:** `git rm --cached <file>`

Showing and Adding Remote Databases

- Every remote that is known to your local repo has:
  - A short name
  - A URL
- To show existing remotes:

```
$ git remote -v
```

- To add a new remote:

```
$ git remote add <remote_name> <url>
```

Getting Commits To and From Remotes

- To send committed, local changes to a remote

```
$ git push <remote_name> <branch_name>
```

- To get the latest changes from a remote

```
$ git pull <remote_name> <branch_name>
```

- By default, your repo will have
  - One remote: “origin”
  - One branch: “master”
- For homeworks, we will use multiple remotes. You won’t need to use multiple branches.