Visibility and Immutabililty

Welcome back to CS 2100!

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Visibility

"Unenforced guidelines and best practices" is a recurring theme in this course.

Python's built-in visibility restrictions

Most programming languages have a way to mark attributes and methods as "private" -- they can only be accessed from within their class

- E.g., block access to `my_diary.password`
- E.g., prevent calling the method `car.spray_gas_from_tank_into_cylinders()`

> "Python doesn't do that. Python doesn't really believe in enforcing laws that might someday get in your way. Instead, it provides unenforced guidelines and best practices. Technically, all methods and attributes on a class are publicly available."
> -- Dusty Philips (the author of our suggested textbook)

In Python, we cannot prevent external code from viewing or changing an object's attributes (or using its methods).

```python
class Diary:
    def __init__(self, username: str, password: str):
        self.username = username
        self.password = password
        self.contents: list[str] = []

    def write_in_diary(self, password: str, content: str) -> None:
        if password == self.password:
            self.contents += [content]
        else:
            print('Wrong password')

my_diary: Diary = Diary('Rasika', 'password123')

# Elsewhere...
my_diary.password = 'Evil password heheh'

# Meanwhile, me at home...
my_diary.write_in_diary('password123', 'I need to vent') # Wrong password
```

However: we put an underscore in the name to nicely ask others to avoid using it

```python
class Diary:
    def __init__(self, username: str, password: str):
        self.username = username
        self._password = password
        self.contents: list[str] = []

    def write_in_diary(self, password: str, content: str) -> None:
        if password == self._password:
            self.contents += [content]
        else:
            print('Wrong password')

my_diary: Diary = Diary('Rasika', 'password123')

# Elsewhere...
my_diary._password = "Intentionally accessing what I shouldn't"

# Meanwhile, me at home...
my_diary.write_in_diary('password123', 'I need to vent')
# Still wrong password, but we asked them nicely not to do this
```

Underscore (`_`) in the name: nicely ask others to avoid using it

> "Most Python programmers will interpret this as, 'This is an internal variable, think three times before accessing it directly'. But there is nothing stopping them from accessing it if they think it is in their best interest to do so. Yet, if they think so, why should we stop them? We may not have any idea what future uses our classes may be put to."
> -- Dusty Philips

Understood convention:

Though we *can* access an attribute named with an underscore, the commonly understood *convention* is that we don't touch it.

It also gets flagged by our linter.

We can ask nicely, or we can strongly suggest it

- Underscore (`_`) in the name: nicely ask others to avoid using it
- *Two* underscores (`__`) in the name: even stronger suggestion to keep away

A double underscore (`__`) *mangles* the name of the attribute: if we want to access it from outside the class, we have to add `_<classname>` to the attribute.

```python
class Diary:
    def __init__(self, username: str, password: str):
        self.username = username
        self.__password = password
        self.contents: list[str] = []

    def write_in_diary(self, password: str, content: str) -> None:
        if password == self.__password:
            self.contents += [content]
            print('it worked')
        else:
            print('Wrong password')

my_diary: Diary = Diary('Rasika', 'password123')

# Elsewhere...
my_diary.__password = "Intentionally accessing what I shouldn't"
# Fails to change __pasword (without showing an error)

# Meanwhile, me at home...
my_diary.write_in_diary('password123', 'I need to vent')
# Works because the password changing didn't work
```

Note: it won't raise an error -- it will just silently fail to access the password attribute.

Use the name mangling: add `_Diary` when accessing from outside the class

```python
class Diary:
    def __init__(self, username: str, password: str):
        self.username = username
        self.__password = password
        self.contents: list[str] = []

    def write_in_diary(self, password: str, content: str) -> None:
        if password == self.__password:
            self.contents += [content]
            print('it worked')
        else:
            print('Wrong password')

my_diary: Diary = Diary('Rasika', 'password123')

# Elsewhere...
my_diary._Diary__password = "Intentionally accessing what I shouldn't"
# Works despite MyPy and Pylint complaints

# Meanwhile, me at home...
my_diary.write_in_diary('password123', 'I need to vent')
# Wrong password
```

> "Name mangling does not guarantee privacy, it only strongly recommends it. Most Python programmers will not touch a double-underscore variable on another object unless they have an extremely compelling reason to do so. However, most Python programmers will not touch a single-underscore variable without a compelling reason either."
> -- Dusty Philips

Poll: Which ONE does NOT make it print `EVIL`?

```python
class Grades:
    def __init__(self, student_id: str):
        self._student_id = student_id
        self.__grades: list[int] = [72, 46]

my_grades: Grades = Grades('S999999')
```

1.

```python
my_grades._student_id = 'EVIL'
print(my_grades._student_id)
```

2.

```python
my_grades.__grades.append(-1)
if -1 in my_grades.__grades:
    print('EVIL')
```

3.

```python
my_grades._Grades__grades.append(-1)
if -1 in my_grades._Grades__grades:
    print('EVIL')
```

4.

```python
print(Grades('EVIL')._student_id)
```

If it's not an attribute (it's a property), it can't be modified

Encapsulation via Properties

Allow external code to modify or access "attributes," but only in a controlled way

- E.g., a `Person` has "attribute" `age: int`, which can be modified, but not to a negative number
- E.g., When we access the `Person`'s `name`, it returns the concatenation of the person's `_first_name` and `_last_name`

To create an attribute that is re-calculated every time someone accesses it, we use the `@property` decorator.

The name of the method marked with the `@property` decorator becomes the name of this attribute.

If it's not an attribute (it's a property), it can't be modified

Encapsulation via Properties

Looks like an attribute called `name`, but is actually the concatenation of two attributes:

```python
class Person:
    def __init__(self, first_name: str, last_name: str):
        self._first_name = first_name
        self._last_name = last_name

    @property
    def name(self) -> str:
        return f'{self._first_name} {self._last_name}'

mini: Person = Person('Mini', 'Bhalerao')
print(mini.name) # Mini Bhalerao
```

`_first_name` and `_last_name` can still be accessed, though it is discouraged.

Properties can be modified, but only through a method that we write and control.

Encapsulation via Properties

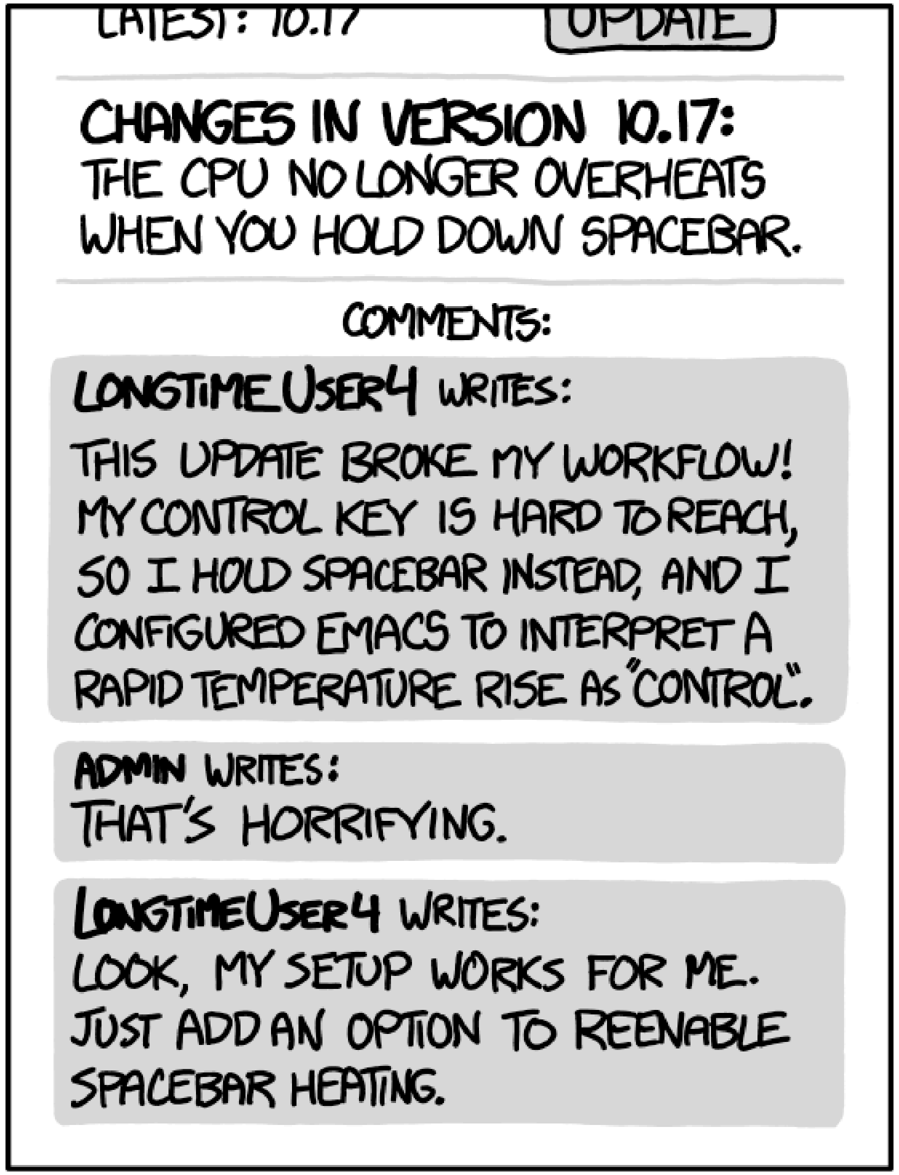
"Attribute" which can only be modified in a controlled way (no negative `age` s):

1. First create the "attribute" using the `@property` decorator
2. Then add a "setter" using another method with the same name, with the decorator `@age.setter`

```python
class Person:
    def __init__(self, age: int):
        self._age = age

    @property
    def age(self) -> int:
        return self._age

    @age.setter
    def age(self, new_age: int) -> None:
        if new_age >= 0:
            self._age = new_age


mini: Person = Person(10)
mini.age = 11
print(mini.age) # 11
```

Poll: Why do we have the decorators `@property` and `@*.setter`?

1. `@property` controls the way outsiders view an attribute
2. `@property` prevents hackers from accessing an attribute
3. `@*.setter` controls the way outsiders can modify an attribute
4. `@*.setter` prevents hackers from modifying an attribute


LATEST: 10.17
UPDATE
CHANGES IN VERSION 10.17:
THE CPU NO LONGER OVERHEATS WHEN YOU HOLD DOWN SPACEBAR.
COMMENTS:
LONGTIMEUSER4 WRITES:
THIS UPDATE BROKE MY WORKFLOW! MY CONTROL KEY IS HARD TO REACH, SO I HOLD SPACEBAR INSTEAD, AND I CONFIGURED EMACS TO INTERPRET A RAPID TEMPERATURE RISE AS "CONTROL".
ADMIN WRITES:
THAT'S HORRIFYING.
LONGTIMEUSER4 WRITES:
LOOK, MY SETUP WORKS FOR ME. JUST ADD AN OPTION TO REENABLE SPACEBAR HEATING.

EVERY CHANGE BREAKS SOMEONE'S WORKFLOW.

Hyrum's Law:

> "All observable behaviors of your system will be depended on by somebody."

https://www.hyrumslaw.com

https://xkcd.com/1172

Immutability

An object is "immutable" if it cannot be modified after creation.

Lists are not immutable, because they can be modified after creation. Lists are mutable.

```
my_list: list[int] = [1, 2, 3]
my_list.append(-400)
print(my_list) # [1, 2, 3, -400]
```

Tuples are immutable.

```
my_tuple: tuple[int, int, int] = (1, 2, 3)
my_tuple.append(4) # impossible
```

Immutability

We can sort a list in-place, but not a tuple.

```
my_list.sort()
print(my_list) # [-400, 1, 2, 3]

my_tuple.sort() # impossible
```

The tricky part:

- The tuple is immutable
- The variable `my_tuple` (the pointer to the location in the computer's memory) is a mutable variable

We can't mutate the tuple, but we can re-assign the variable `my_tuple` to a sorted version of the same tuple:

```python
my_long_tuple: tuple[int, ...] = tuple([-i for i in range(5)])
my_long_tuple = tuple(sorted(my_long_tuple))
print(my_long_tuple)      # (-4, -3, -2, -1, 0)
```

Poll: Which ONE is not allowed? (Hint: `str`s are immutable)

```python
my_str: str = 'mini'
```

1. `print(my_str.upper())`
2. `my_str = my_str.upper()`
3. `my_str = 'MINI'`
4. `my_str[0] = 'B'`

Poll:

1. What is your main takeaway from today?
2. What would you like to revisit next time?