COMP 204
Object Oriented Programming (OOP)

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Object-Oriented Programming

- OOP is a way to write and structure programs to make them easier to design, understand, debug, and maintain.
- It allows putting together (i.e. encapsulating) all the data that pertains to a certain concept, along with the functions (called Methods) that operate on it.
- Nearly all large-scale software projects are written using OOP.
- Became popular in the 90’s.
Remember our bus simulation code. It had the information relative to a given bus dispersed over many variables:

- bus_station (dictionary mapping busID to stations)
- bus_content (dictionary mapping busID to list of people on board)

We could also have needed a lot more information: name of driver, capacity of bus (different bus may have different capacities), etc.

Having all this data in separate dictionaries makes the code complex and slow.
Classes

A **class** can also be thought of as a template that defines what type of information we can to keep together (attributes), and what we want to be able to do with it (Methods).

We have used Python built-in classes (aka compound types) before:

- **String**: Contains some data (the characters), and some methods that can be applied to that data (isdecimal(), split(), etc.)
- **List**: Contains an ordered sequence of objects. Methods: sort(), append(), etc.
- **Dictionary**: Contains a set of tuple (key,value). Methods: items(), keys(), etc.
Objects

To make use a class, we need to create objects of that class. An **object** is an instantiation of a class that contains all the data for a particular example of that class. A class can have multiple objects instantiated from it, each with its own data, but all built from the same template.

```python
students_204 = list()  # could also write students = []
students_561 = list()

# students_204 and students_561 are two different objects of the same class

# We can store different values within them by calling the append method
students_204.append("Samy")
students_204.append("Nadia")

students_561.append("Yan")
students_561.append("Alina")

# we can call the sort method to sort them
students_204.sort()
# students_204 is now ["Nadia", "Samy"]
# students_561 is still ["Yan", "Alina"]
```
OOP: Creating our own classes

Python allows us to define our own classes. A class contains two types of information:

- **Attributes**: Different pieces of information that will be stored within objects of that class. Attributes can be objects of any type: integers, Strings, Lists, Dictionaries, or objects belonging to user-defined classes.

- **Methods**: Functions that can be executed on objects of that class
We create a new class called `Bus`, which contains the following attributes: station, capacity, passengers, terminus.

```python
class Bus:
    def __init__(self):
        self.station = 0  # the position of the bus
        self.capacity = 5  # the capacity of the bus
        self.passengers = []  # the content of the bus
        self.terminus = 5  # The last station

    # end of Bus class definition

knight = Bus()  # creates a object of class Bus,
                # assigns it to variable knight

desire = Bus()  # creates a object of class Bus,
                # assigns it to variable desire

print(knight.capacity)  # access attributes using the .

if desire.station==desire.terminus:
    print("Desire has reached its terminus")
```

Note: Each object of class `Bus` has its own set of values for these attributes.
Objects created from user-defined classes are mutable

We change the values of attributes of an object.

class Bus:
    def __init__(self):
        self.station = 0 # the position of the bus
        self.capacity = 5 # the capacity of the bus
        self.passengers = [] # the content of the bus
        self.terminus = 5 # The last station

# end of Bus class definition

knight = Bus()
desire = Bus()

# We can change the value of an object's attributes
knight.station = 1
desire.station = knight.station + 2

knight.passengers.append(3)
The initializer method (aka constructor):

- Defines what the attributes of the class are, and how to initialize them.
- Created using syntax: `def __init__(self):`
- Gets executed when we create a new object of that class. For example: `knight = Bus()`
- Should always take at least one argument, called `self`.
  - `Self` refers to the object that is being initialized.
  - When we write `self.capacity = 5`, this means: assign value 5 to the attribute `capacity` of the object being created.
- Any class definition should include an initializer method
A more flexible initializer

class Bus:
    def __init__(self, station=0, capacity=5,
                 passengers=[], terminus=5):
        self.station = station
        self.capacity = capacity
        self.passengers = passengers
        self.terminus = terminus
    # end of Bus class definition

# We create an object of class Bus, initialized
# with station=0, capacity=5, passengers=[2,4], terminus=4
knight=Bus(station=0, capacity=5, passengers=[2,4], terminus=4)
desire=Bus()  # creates an object of class Bus, initialized
    # with default values
Defining class methods

We can define other methods within a class.
Each method takes as argument self, plus possibly more.

class Bus:
    def __init__(self, ...):
        # Same as before

        # Define the move method, which moves
        # the bus up by one station
        def move(self):
            if self.station < self.terminus:
                self.station += 1

knight=Bus(station=0, capacity=5, passengers=[2,4], terminus=4)
desire=Bus()

knight.move()  # knight.station is now 1
knight.move()  # knight.station is now 2
desire.move()  # desire.station is now 1

To call a method on an object, we write my_object.my_method().
Note: All methods take self as first argument. However, when
calling the method, it is not explicitly provided as an argument.
Instead, self refers to the object on which the method is called.
class Bus:
    def __init__(self, ...):
        # Same as before

    def move(self):
        # Same as before

    def unload(self):
        # Removes passengers who have reached their station
        # Returns number of passengers who disembark
        out = [d for d in self.passengers if d==self.station]
        self.passengers = [d for d in self.passengers if d!=self.station]
        return len(out)

knight = Bus(station=0, capacity=5, passengers=[2, 4, 2], term=4)
knight.move()  # knight.station is now 1
knight.move()  # knight.station is now 2

disembarked = knight.unload()  # disembarked is now 2
class Bus:
    def __init__(self, ...):
        # Same as before
    def move(self):
        # Same as before
    def unload(self):
        # Same as before

    def load(self, waiting_line):
        # lets people in waiting_line embark, until bus full
        # Returns the number of people who boarded
        number_boarding = min(len(waiting_line),
                                self.capacity - len(self.passengers))
        people_boarding = waiting_line[0:number_boarding]
        self.passengers.extend(people_boarding)
        return number_boarding

knight=Bus(station=0,capacity=5,passengers=[2,4,2],term=4)
knight.move()  # knight.station is now 1
knight.move()  # knight.station is now 2
disembarked = knight.unload()
print(disembarked)  # prints 2
print(knight.passengers)  # prints [4]
nb_loaded = knight.load([4,5,3,5,4,3])
print(knight.passengers)  # prints [4,4,5,3,5]
Putting it all together

See busSim_object_oriented.py

Notice how much simpler the simulation loop becomes!

Advantage: All the code that pertains to the bus behavior is in the Bus class. The programmer of the simulation loop does not need to know all the details of the Bus class. It only needs to know how to use its methods properly.