FLOWMINDER.ORG

Object-Oriented Software Development (in Python)

L. Pitonakova

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

FLOWMINDER.ORG

I will talk about...

- Basic principles of OO Software development
- Examples
- Class diagrams (UMLs)
- Design patterns we use in our software
- Enumeration

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

What is OO

- Software development paradigm based on “objects”
  - Attributes (data)
  - Methods (code)
- Objects belong to classes (type of object)
  - Define what attributes and methods an object will have
- Objects are instances of classes
  - I.e. they exist in memory

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

- Dog class

- Attributes
  - Eye colour (passed when creating a new dog)
  - Number of bones collected (set to 0 when a new dog is created)

- Methods
  - ‘Constructor’ – in python, this is replaced by the __init__ function
  - A method to collect a new bone

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Example

```
class Dog():
    def __init__(self, eye_color):
        self.__eye_color = eye_color
        self.__bones_collected = 0

    def collect_bone(self):
        # do something to find it
        self.__bones_collected += 1
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
# instantiate a dog
my_dog = Dog('green')

# tell dog to do something
my_dog.collect_bone()
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Encapsulation

- Objects can have private or public attributes and methods
  - Private: only the object is able to access it. Use of the ‘self’ keyword.
  - Public: any other object can access it

- Objects should generally be responsible for maintaining their internal variables and provide methods for other objects to access / change them.
  - Good code maintainability
  - Less errors when using someone’s else’s class

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Encapsulation

- In python, the concept is not strictly implemented, but we can use tricks..
  - Private attributes and methods have the '__' prefix. Some editors will hide such attributes / methods from intellisense
  - Use of property decorators to turn private attributes into something that looks like a public variable. Effectively, create 'getter' and 'setter' methods.

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Example

```
class Dog():
    def __init__(self, eye_color):
        self.__eye_color = eye_color
        self.__bones_collected = 0

    def collect_bone(self):
        # do something to find it
        self.__bones_collected += 1
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
@property
def bones_collected(self):
    return self.__bones_collected;

@bones_collected.setter
def bones_collected (self, value):
    self.__bones_collected = value
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
# instantiate a dog and make it collect a bone
my_dog = Dog('green')
my_dog.collect_bone()

#use the proper getter for __bones_collected
print(my_dog.bones_collected)
[Out:] 1

#use the proper setter for __bones_collected
my_dog.bones_collected = 5
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Inheritance

- Classes can be organised in a hierarchy. ‘Child’ classes inherit everything from their ‘parent’ classes.

- Very useful for letting multiple classes share similar functionality but diverge on other
  - Common functionality in parent
  - Children implement their own additional attributes and methods
  - Improves code readability and maintainability

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Inheritance

- Parent class provides a common init method that all children should call in their own init functions
- Parent class can also implement other methods – directly usable by children using the self keyword
- Children can override a method of the parent to replace / add to the method's functionality
  - When a method is overriden, the child's functionality is executed
  - Call super().method_name() to also get parent's functionality

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Example

```
class Animal():
    def __init__(self, eye_color):
        self.__eye_color = eye_color
        self.__hunger_level = 50
        print("Animal with " + eye_color + " eyes")

    def eat(self, amount):
        self.__hunger_level -= amount
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
@property
def hunger_level(self):
    return self.__hunger_level

# no setter for hunger level – animal has
# to eat to decrease it
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
class Dog(Animal):
    def __init__(self, eye_color):
        super().__init__(eye_color)
        self.__bones_collected = 0
        self.__hunger_level = 100
        print("A new dog")

    def collect_bone(self):
        # do something to find it
        self.__bones_collected += 1
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
class Cat(Animal):
    def __init__(self):
        super().__init__('black')
        print("A new cat")

    def climb_tree(self):
        # climb a tree
        print("I'm climbing a tree")
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
# instantiate a dog
my_dog = Dog('green')
[Out:] Animal with green eyes
[Out:] A new dog

# instantiate a cat
my_cat = Cat()
[Out:] Animal with black eyes
[Out:] A new cat
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
# tell the dog to eat
my_dog.eat(10)

# find out hunger level
print(my_dog.hunger_level)
[Out:] 90
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
# create another dog and tell it to eat
my_dog_2 = Dog(“blue”)
[Out:] Animal with blue eyes
[Out:] A new dog
my_dog_2.eat(50)
print(my_dog_2.hunger_level)
[Out:] 50
print(my_dog.hunger_level)
[Out:] 90
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Member types

- Attributes and methods are commonly referred to as ‘members’ of a class

- In Python, members can be of three types:
  - Instance – each object creates their own copy
  - Class - only one copy shared between all objects of the class. Usually used for alternative constructors
  - Static – no references to class or instance passed. Used usually for high-level functions (it doesn’t have access to any non-static members)

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Member types

- Define instance attributes inside of the __init__ method
- Define class / static attributes on class level, by convention before the __init__ method definition. Use capitals.

- Always pass self as the 1st parameter to instance methods
- Always pass class as the 1st parameter to class methods. Use the @classmethod decorator
- Static methods do not have any obligatory parameters. Use the @staticmethod decorator

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
class Animal():

    HOME_PLANET = “Earth”

    def __init__(self, eye_color):
        ...
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
@classmethod
def from_hunger_level(cls, hunger_level,
                      eye_color):
    # do some work ...
    # instantiate
    new_animal = cls(eye_color)
    # do extra things to the instance
    new_animal.__hunger_level = hunger_level
    return new_animal
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
@staticmethod
def get_hex_from_color(color):
    if (color == “green”):
        return “00FF00”
    if (color == “blue”):
        return “0000FF”
    if (color == “black”):
        return “000000”
    return “”
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
class Dog(Animal):

    NUMBER_OF_LEGS = 4

    def __init__(self, eye_color):
        ...
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
# standard constructor
my_dog = Dog(“green”)
print(my_dog.hunger_level)
[Out:] 100

# alternative constructor
my_dog_2 = Dog.from_hunger_level(40, “blue”)
print(my_dog_2.hunger_level)
[Out:] 40
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
# use of static attribute
print(Animal.HOME_PLANET)
[Out:] Earth

print(my_dog.HOME_PLANET)
[Out:] Earth

print(my_dog.NUMBER_OF_LEGS)
[Out:] 4
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
my_cat = Cat()

print(my_cat.HOME_PLANET)
[Out:] Earth

print(my_cat.NUMBER_OF_LEGS)
[Out:] <Error>
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
# use of static method
print(Animal.get_hex_from_color('black'))
[Out:] 000000

print(Animal.get_hex_from_color(my_dog.eye_color
))
[Out:] 00FF00
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Method overriding

- When a method overridden, the child's implementation will always be called
  - Great for replacing or extending parent's functionality

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
class Animal():
    def __init__(self, eye_color):
        self.__eye_color = eye_color
        self.__hunger_level = 50
        print("Animal with " + eye_color + " eyes")

    def eat(self, amount):
        self.__hunger_level -= amount
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
class Dog(Animal):
   ...
   def eat(self, amount):
      if (self.__bones_collected > 0):
         super().eat(amount)
         self.__bones_collected -= 1
      else:
         print("Not enough bones")
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Method overriding

- Also useful for creating ‘virtual’ methods on the parent class level, ‘forcing’ child classes to implement their own functionality

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
class Animal():
    ...
    def stalk_prey(self):
        raise Exception("Class " +
            str(self.__class__) + " doesn't
            implement stalk_prey ()")
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
class Dog(Animal):
    ...
    def stalk_prey(self):
        print("Dog is stalking the prey now...")
        # no call to super!
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Example

```
my_dog.stalk_prey()
[Out:] Dog is stalking the prey now...

my_cat.stalk_prey()
[Out:] <Error> Class Cat doesn't implement
stalk_prey()
```

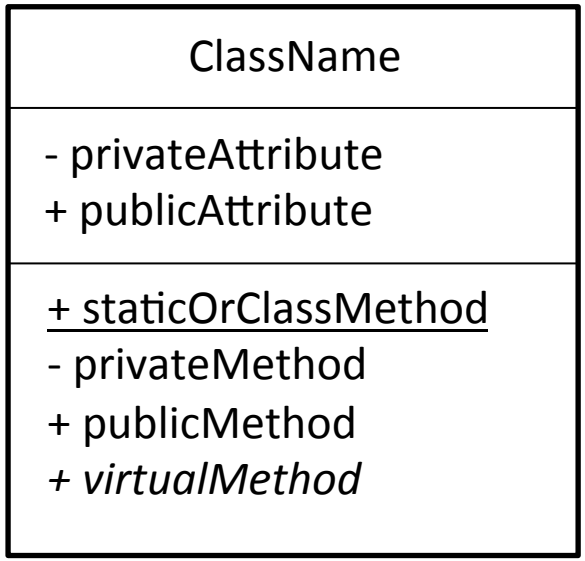
Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

The Class Diagram (UML)

- A visualisation for class hierarchies and responsibilities

- Class

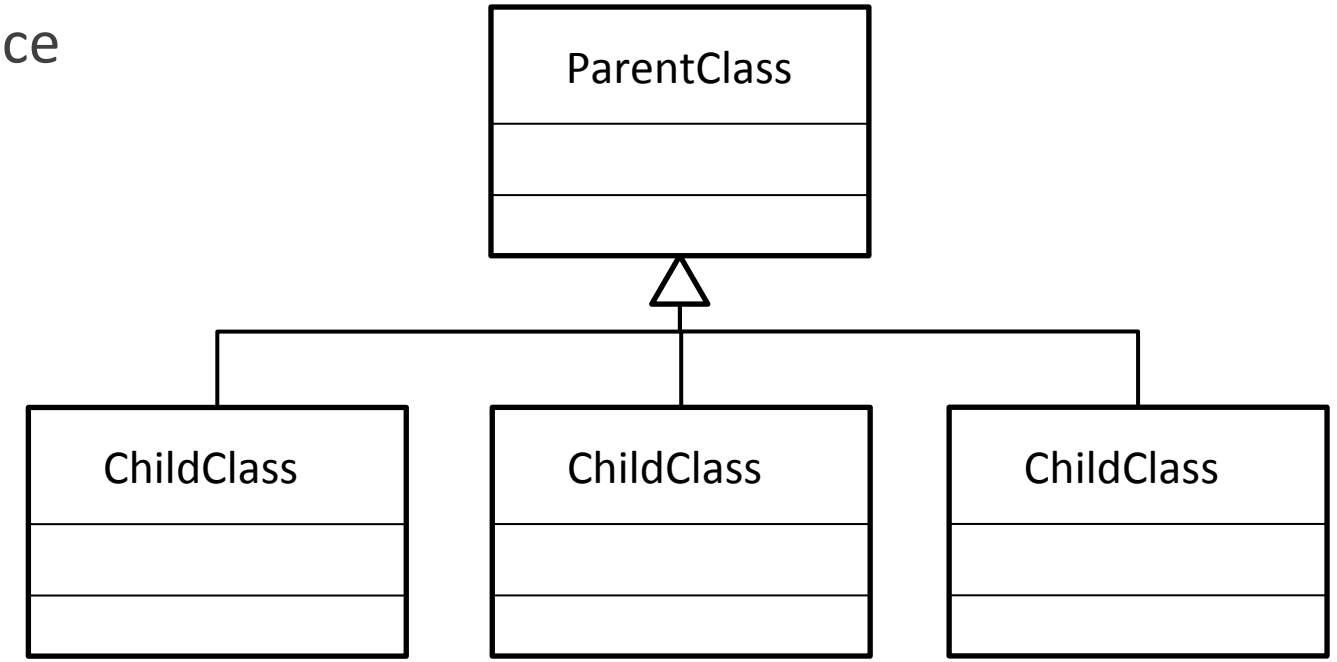


Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

The Class Diagram (UML)

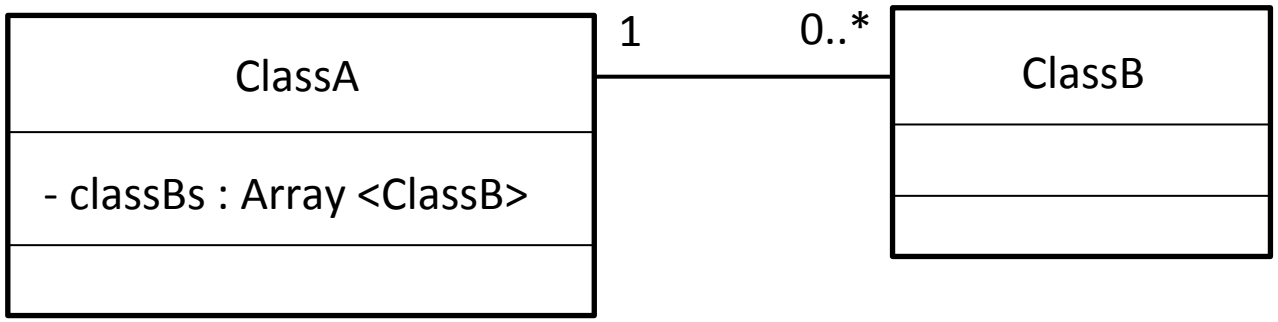
- Inheritance



Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

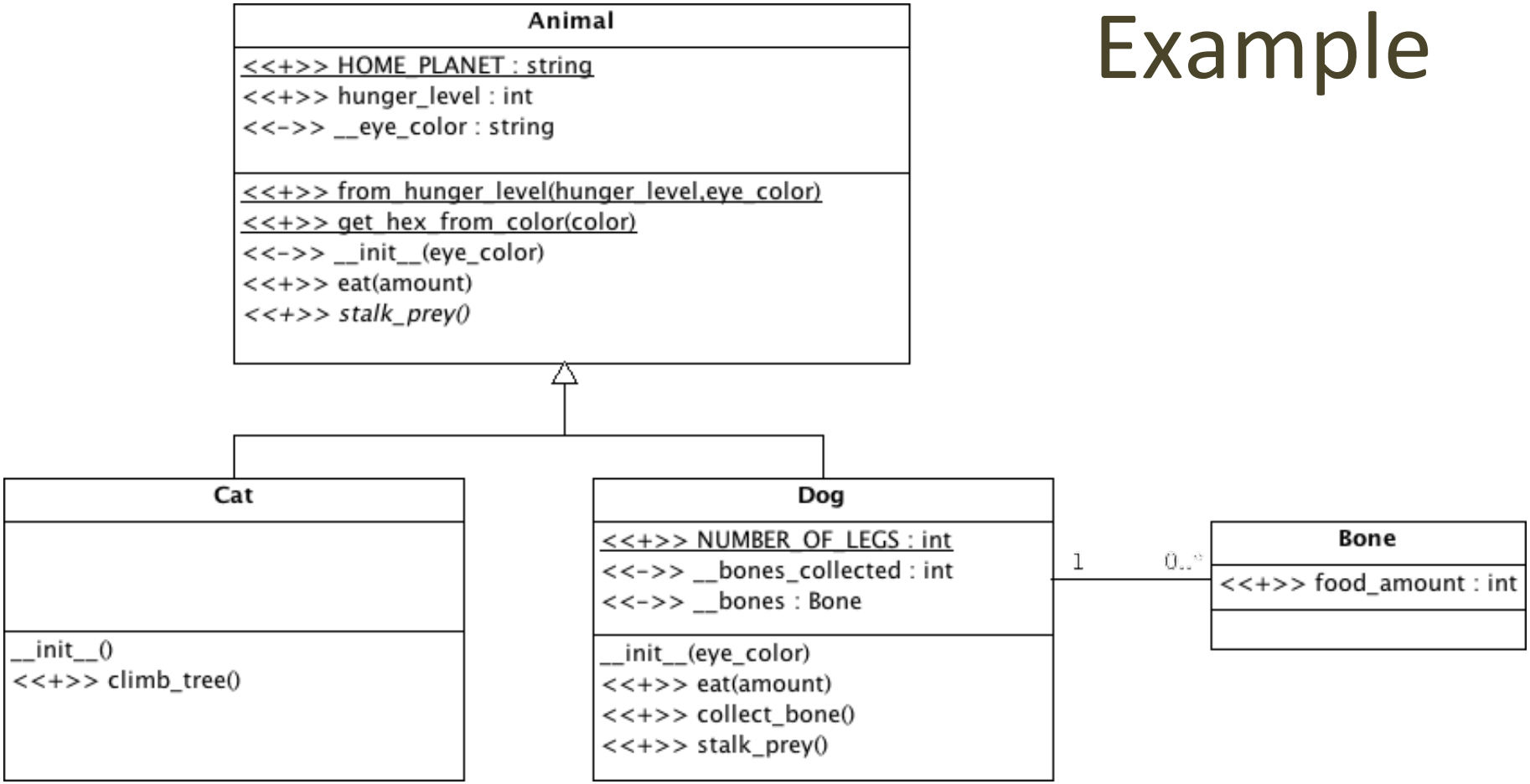
The Class Diagram (UML)

- Association



Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Example



Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Design patterns

- Well-tested solutions to common problems in software development
- Guide to programmers:
  - What responsibilities should classes have?
  - What class hierarchy should there be?
  - How should classes be instantiated?
  - Where should data be stored / used ?
  - Etc.

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

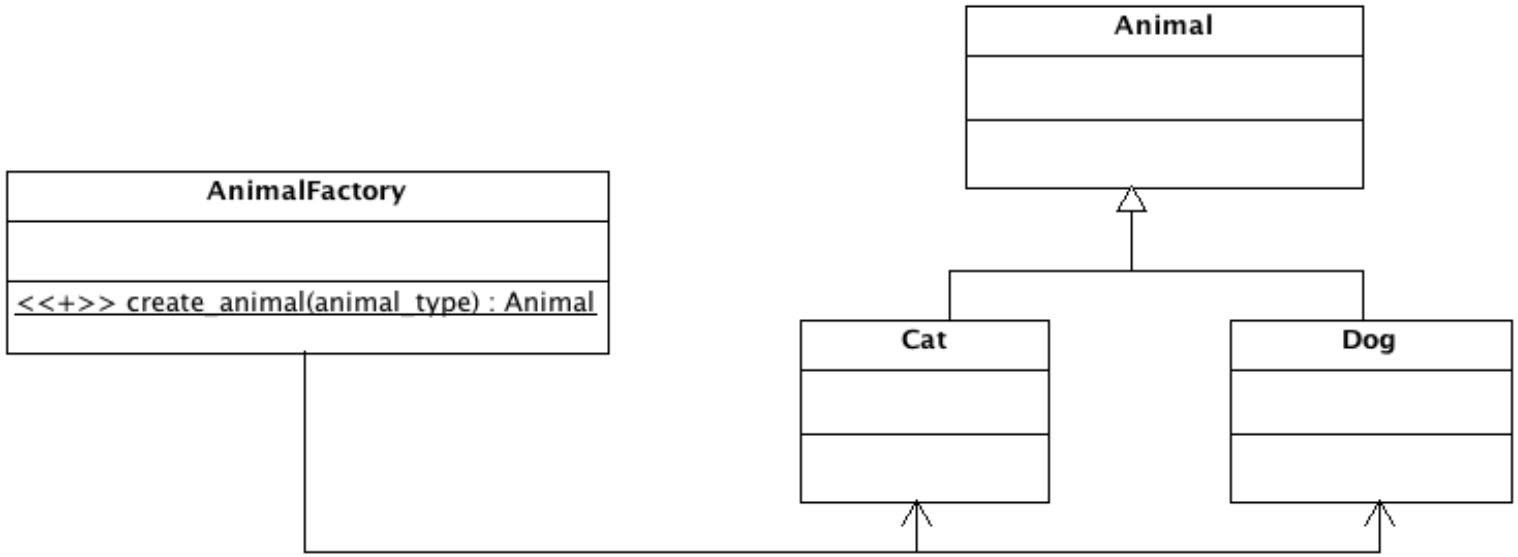
Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Factory method pattern

- Create a ‘factory’ method responsible for instantiating other classes based on some parameters
  - Used when new class of a desired object is only known at run-time
  - Processes logic for what type a new instance should be and returns that instance

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Factory method pattern



Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Factory method pattern

```
class AnimalFactory():
    @staticmethod
    def create_animal(animal_type):
        if (animal_type == “dog”):
            return Dog(“blue”)
        if (animal_type == “cat”):
            return Cat()
        raise ValueError(“Unknown animal type: ”
            + animal_type)
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Factory method pattern

```
# ask user what they want
print("What animal would you like?")
choice = input().lower()
[In:] dog

# use the factory
my_animal = AnimalFactory.create_animal(choice)
[Out:] Animal with blue eyes
[Out:] A new dog
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

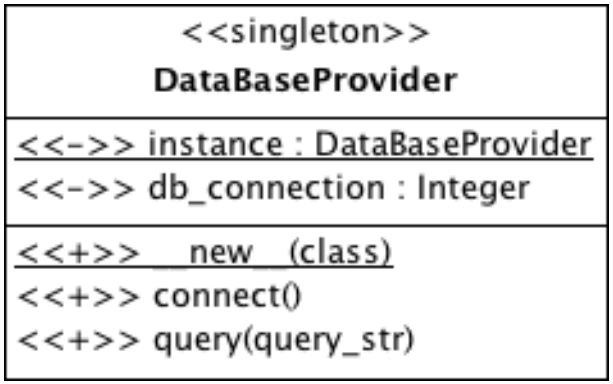
Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Singleton pattern

- Only allow one instance per class, that is not owned by any other instance
  - Only 1 object exists in memory
  - Allows that object (and its instance attributes) to be shared across all objects
  - Useful e.g. to hold common settings in an application or to hold 1 database connection

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Singleton pattern



Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Singleton pattern

```
class DatabaseProvider():
    _instance = None

    def __new__(class, *args, **kwargs):
        if not isinstance(class._instance, class):
            # only executed once in a program
            print("Database provider created")
            class._instance = object.__new__(class, *args, **kwargs)
            # set intance attributes here
            class._instance.db_connection = None

        return class._instance
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Singleton pattern

```
def connect():
    if (db_connection is None):
        print("Connecting")
        # connect to the database...
        db_connection = ...

def query(query_str):
    # check for connection
    if (db_connection is None):
        self.connect()
    # do the query...
    print("Querying")
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Singleton pattern

```
# create the provider the first time
my_db = DatabaseProvider()
my_db.query("MY QUERY")
[Out:] Database provider created
[Out:] Connecting
[Out:] Querying

...
# later in the code, try to create it the second time
my_db_2 = DatabaseProvider()
my_db_2.query("MY QUERY")
[Out:] Querying
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

The Enumeration (Enum)

- Provide a set of acceptable values
  - Useful when a method needs to accept a parameter ONLY with certain values – e.g. colours, animal types, etc.
  - Hint for programmer who uses the method
  - Opens the ability to type check the argument
  - If values are integers, can be used if for loops

- In more 'classic' OO languages, Enum is a custom data type
- In Python, Enum is technically a class
- Usually defined before definition of a class that most uses it

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

The Enumeration (Enum)

```
from enum import Enum, unique

@unique
class EYE_COLOR(Enum):
    GREEN = "green"
    BLUE = "blue"
    BLACK = "black"

class Animal():
    def __init__(self, eye_color:EYE_COLOR):
        if not (isinstance(eye_color, EYE_COLOR)):
            raise TypeError("Invalid eye color")
        print("Animal with " + eye_color.value + " eyes")
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

The Enumeration (Enum)

```
@staticmethod
def get_hex_from_color(color:EYE_COLOR):
    if not (isinstance(eye_color, EYE_COLOR)):
        raise TypeError("Invalid eye color")

    if (color == EYE_COLOR.GREEN):
        return "00FF00"
    if (color == EYE_COLOR.BLUE):
        return "0000FF"
    if (color == EYE_COLOR.BLACK):
        return "000000"

    return "! Warning eye color not handled"
```

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Summary

- We learned what OO means
  - Classes vs. instances
  - Attributes vs. methods
  - Encapsulation, member types
  - Inheritance
  - Method overriding

- Class diagrams (UMLs)
  - Useful for visualisation of class hierarchies and responsibilities

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.

Summary

- Design patterns
  - Factory method: provide a single method to instantiate objects, when class of an object is only known at run-time
  - Singleton: provide a single instance per class, when that instance's attributes need to be readily shared between various pieces of code

- Enumeration
  - Provide a new 'data type' to precisely specify acceptable values

Contacts:
linus.bengtsson@flowminder.org +41 78 964 88 28
erik.wetter@flowminder.org +46 70 893 88 37
andy.tatem@flowminder.org +44 7703 392 192

Flowminder.org is a non-profit organization registered in Stockholm, Sweden. Ncell is a mobile operator in Nepal and part of the TeliaSonera group. Analyses are based on de-identified mobile network data and conducted in accordance with mobile industry (GSMA) *Guidelines on the protection of privacy in the use of mobile phone data for responding to the Ebola outbreak,* published October 2014.