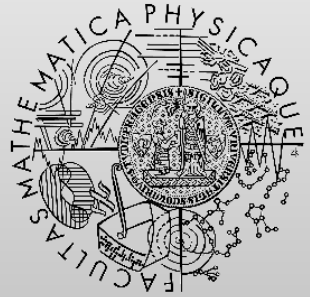
NPRG065: Programming in Python
Lecture 8

http://d3s.mff.cuni.cz



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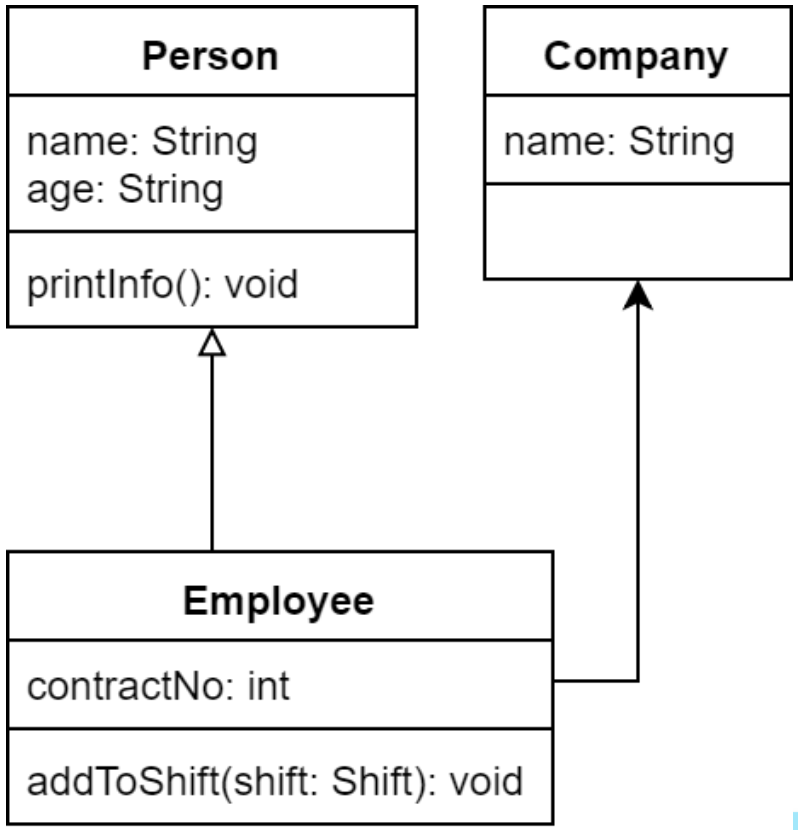
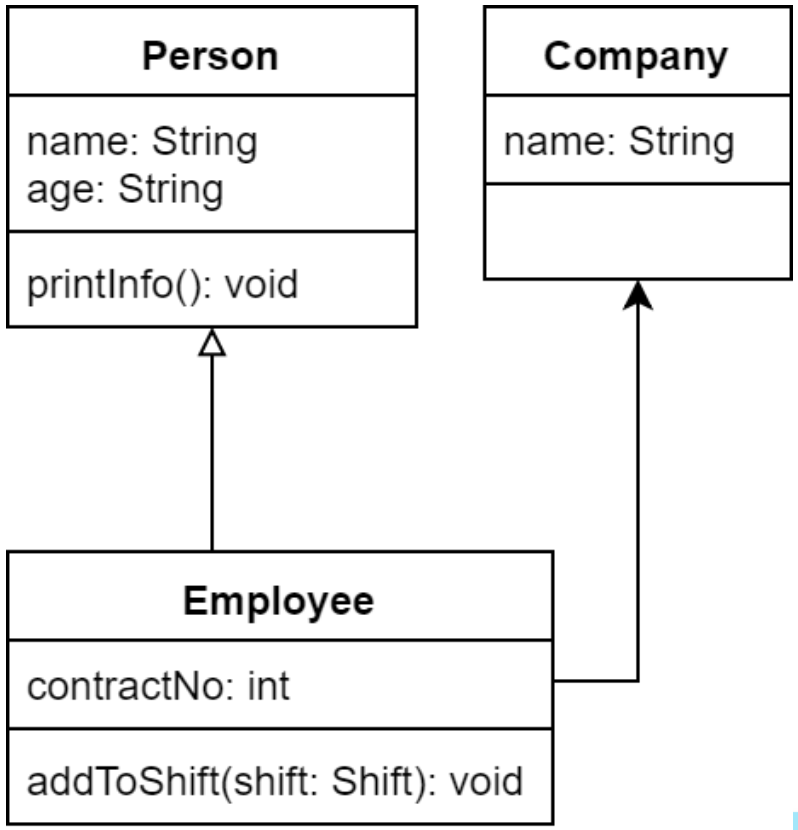
Object-oriented programing – Basic principles

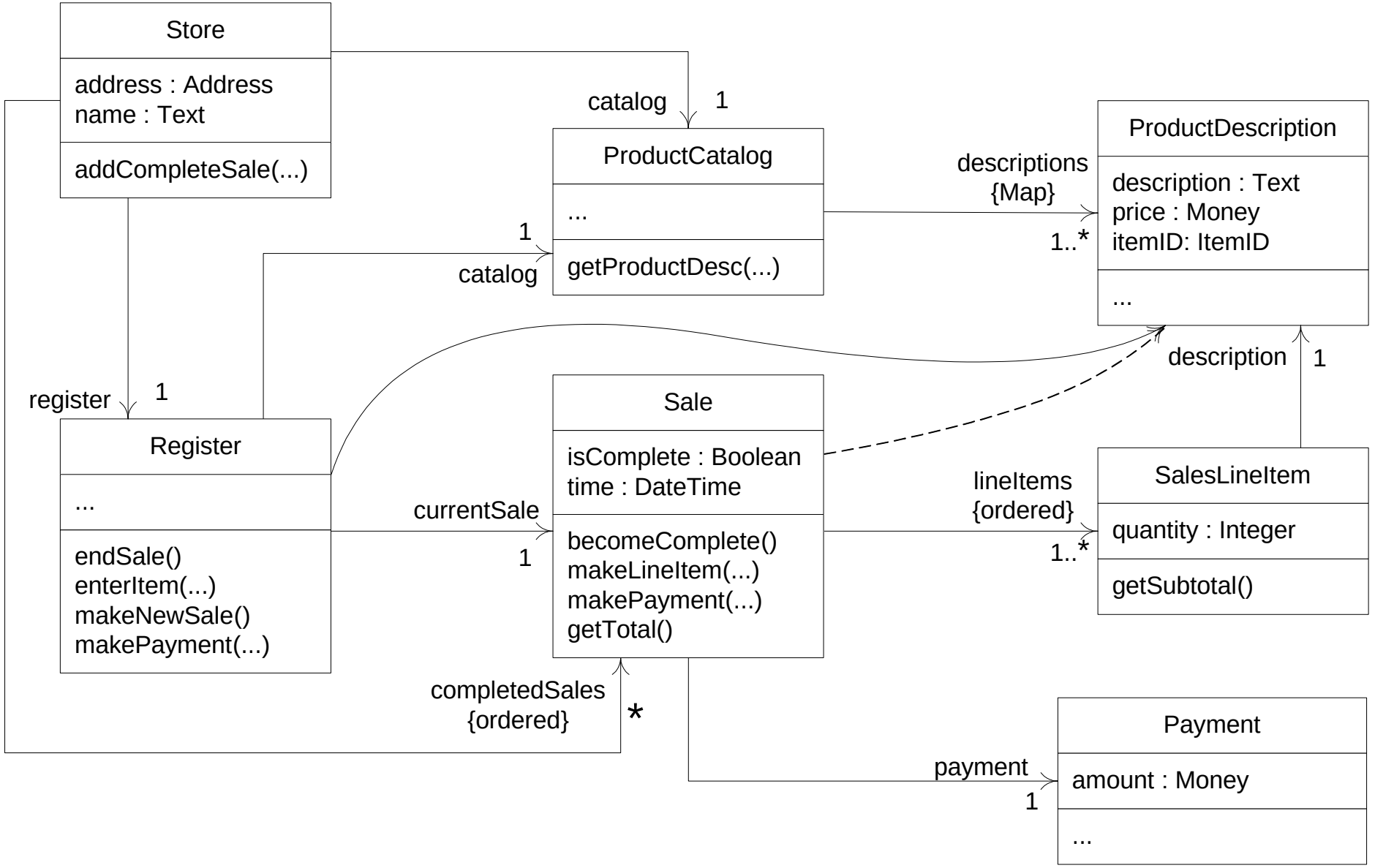
- A system consists of a set of objects that are send messages to each other.
- The reception of a message triggers an operation in the receiving object.
- An object is an individual entity with a unique identity.
- A class describes a set of objects with common characteristics:
  - Attributes (e.g., name, age of a person)
  - Relationships to other objects (e.g. a person is married to another person)
  - Operations that can be executed (e.g. printInfo)



Object-oriented programing – Basic principles

- The current attribute values (and relationships) at a time determines the object's state
- The current state of all existing objects at a time (and their relationships to other objects) determine the system's state
- Classes can be specialized –
  e.g., an employee is a person
- Fundamental OO concepts
  - Encapsulation
    - Hides particular details
  - Abstraction (inheritance)
    - An “employee” can be regarded as a “person”
  - Polymorphism
    - Behavior dependent on a particular instance





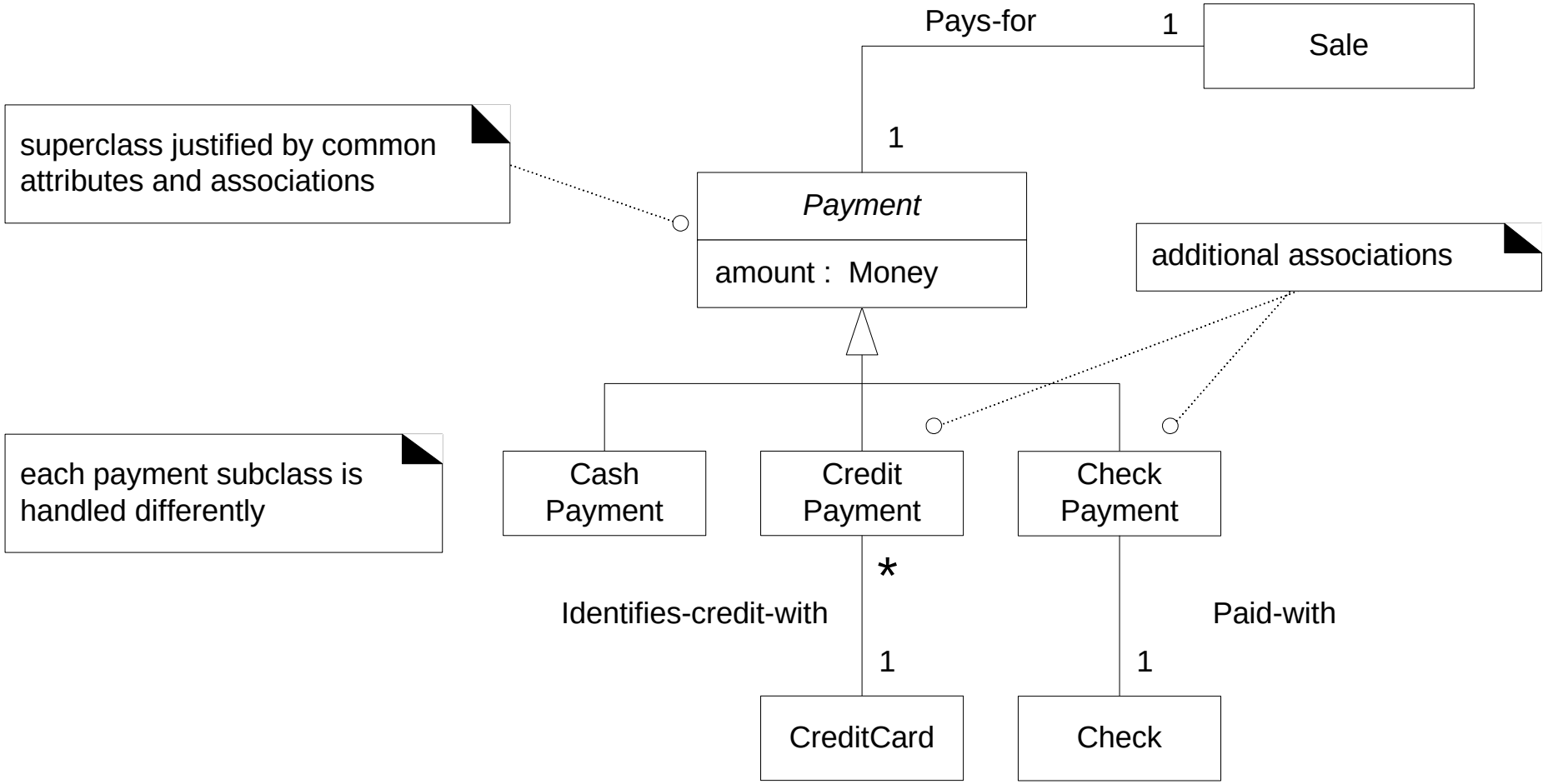


Figure from slides of C. Larman: http://www.craiglarman.com/wiki/index.php?title=Educator_Resources

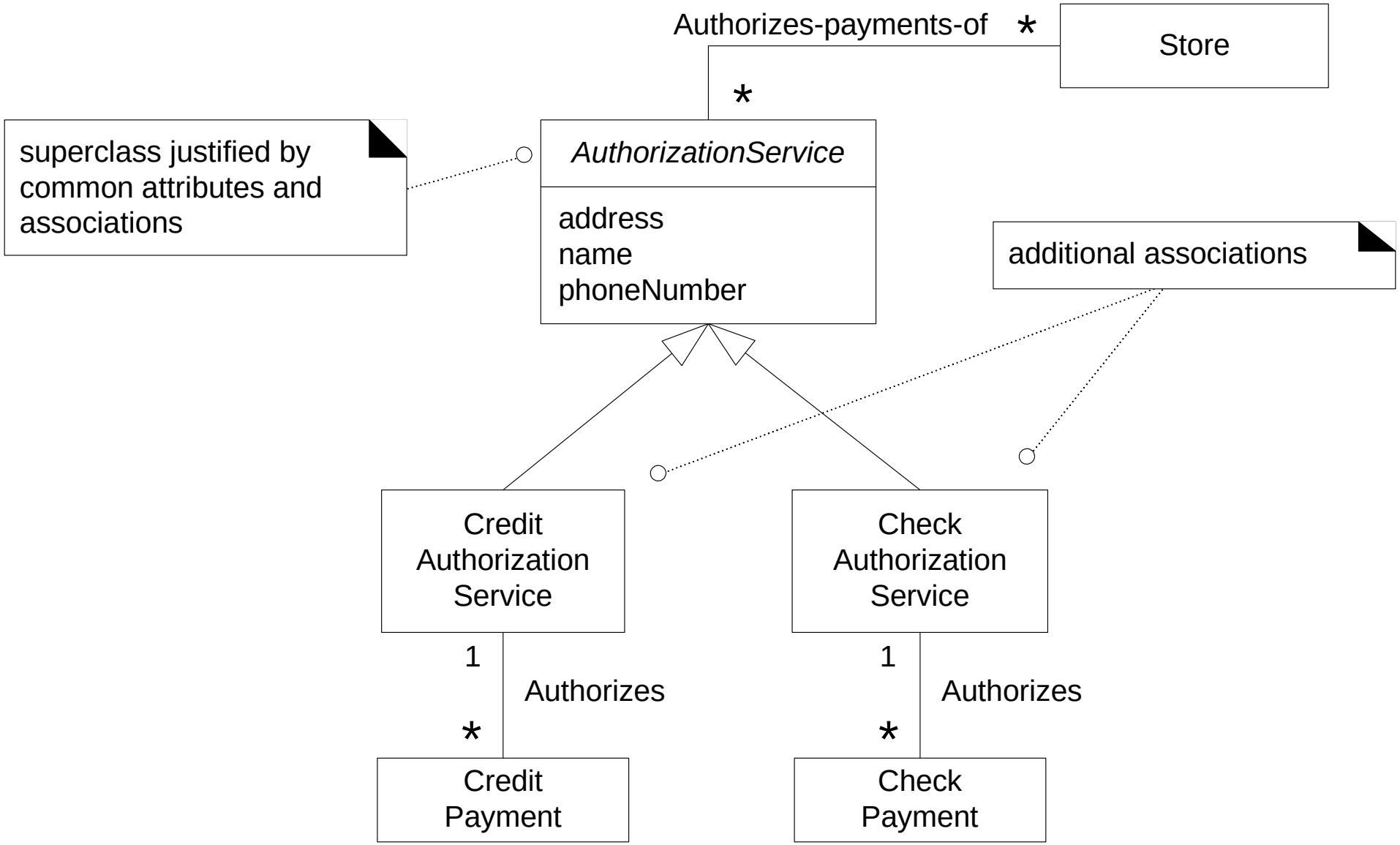


Figure from slides of C. Larman: http://www.craiglarman.com/wiki/index.php?title=Educator_Resources

Classes and objects

- Class ~ (in broad view) a template for creating objects
- Object ~ an instance of a class

- In Python
  - class defined as a set of statements

```
class ClassName:
    <statement-1>
    .
    .
    <statement-N>
```

  - Note – in Python, a class definition is also an object
    - will be later in more details

Basics of classes

```
class Dog:
    kind = 'canine'

    def __init__(self, name):
        self.name = name

    def bark(self):
        print(f'{self.name} says: Woof woof')

print(Dog.kind)         # -> canine
d = Dog('Fido')         # instantiating new objects
e = Dog('Buddy')
print(d.kind)           # -> canine
print(e.kind)           # -> canine
print(d.name)           # -> Fido
print(e.name)           # -> Buddy
d.bark()                # Fido says: Woof woof
e.bark()                # Buddy says: Woof woof
```

Class variable (similar to static field in Java)

Initialization method (like a constructor)

Explicit reference to objects (like **`this`** in Java)

No “new” for instantiating

Examine and run basics_classes.py

self is set automatically

Basics of classes

- Method calls

```
d = Dog('Fido')
Dog.bark(d)       # equivalent to   d.bark()
```

- Calling methods like functions

```
dbark = d.bark
dbark()
```

- Class variables – shared among all instances
- Object variables defined in **`__init__()`**
  - but can be defined in any method
  - or even outside of any method

Examine and run methods_variables.py

Basics of classes

- Functions can be “transformed” to methods

```
def f1(self, x, y):
    return x + y

class C:
    f = f1

    def g(self):
        return 'hello world'

    h = g

    # now, all f, g, and h are methods
```

  - functions and methods are objects too
    - will be later in more detail

Examine and run functions_methods.py

Inheritance

```
class DerivedClassName(BaseClassName):
    <statement-1>
    .
    .
    .
    <statement-N>
```

- Methods can be overridden
  - effectively, all the methods are virtual (like in Java)
  - calling a method from the parent in the overridden method
    `BaseClassName.methodname(self, arguments)`
  - or (and better)
    `super().methodname(arguments)`
- Builtin functions
  - **`isinstance(obj, clazz)`**
  - **`issubclass(clazz, parent_class)`**

Multiple inheritance

```
class DerivedClassName(Base1, Base2, Base3):
    <statement-1>
    .
    .
    .
    <statement-N>
```

- Searching a method/variable in parents
  - generally depth-first, left-to-right

Not completely true …
details will follow

Examine and run
multiple_inheritance_basics.py

Inheritance

- All classes inherit (directly or indirectly) from **`object`**

- Good practice (especially with multiple inheritance)
  - Always call inherited **`__init__()`** method
    - all of them
  - **`super().__init__()`**

Examine and run
multiple_inheritance_bad.py
And
multiple_inheritance_ok.py

Linearization

- Searching a method/variable in parents
  - uses C3-linearization (aka Method Resolution Order – MRO)
  - ordering of ancestors such that:
    - ancestor never comes before a child (local precedence order)
    - an ancestor is not visited twice
  - within those rule it builds the MRO depth-first, left-to-right

Examine and run linearization.py