Object Fundamentals, Part One

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Lecture Goals

- Introduce basic concepts, terminology, and notations for object-oriented analysis, design, and programming
  - A benefit of the OO approach is that the same concepts appear in all three stages of development
- Start with material presented in Appendix II of your textbook
  - Continue (in lecture 3) with additional material from previous versions of this class as well as from **Head First Java** by Sierra & Bates, © O'Reilly, 2003
- Will present examples and code throughout

Big Picture View

- OO techniques view software systems as
    - **systems of communicating objects**
- Each object is an **instance** of a **class**
    - All objects of a class share similar **features**
        - **attributes**
        - **methods**
    - Classes can be **specialized** by subclasses
- Objects communicate by **sending messages**

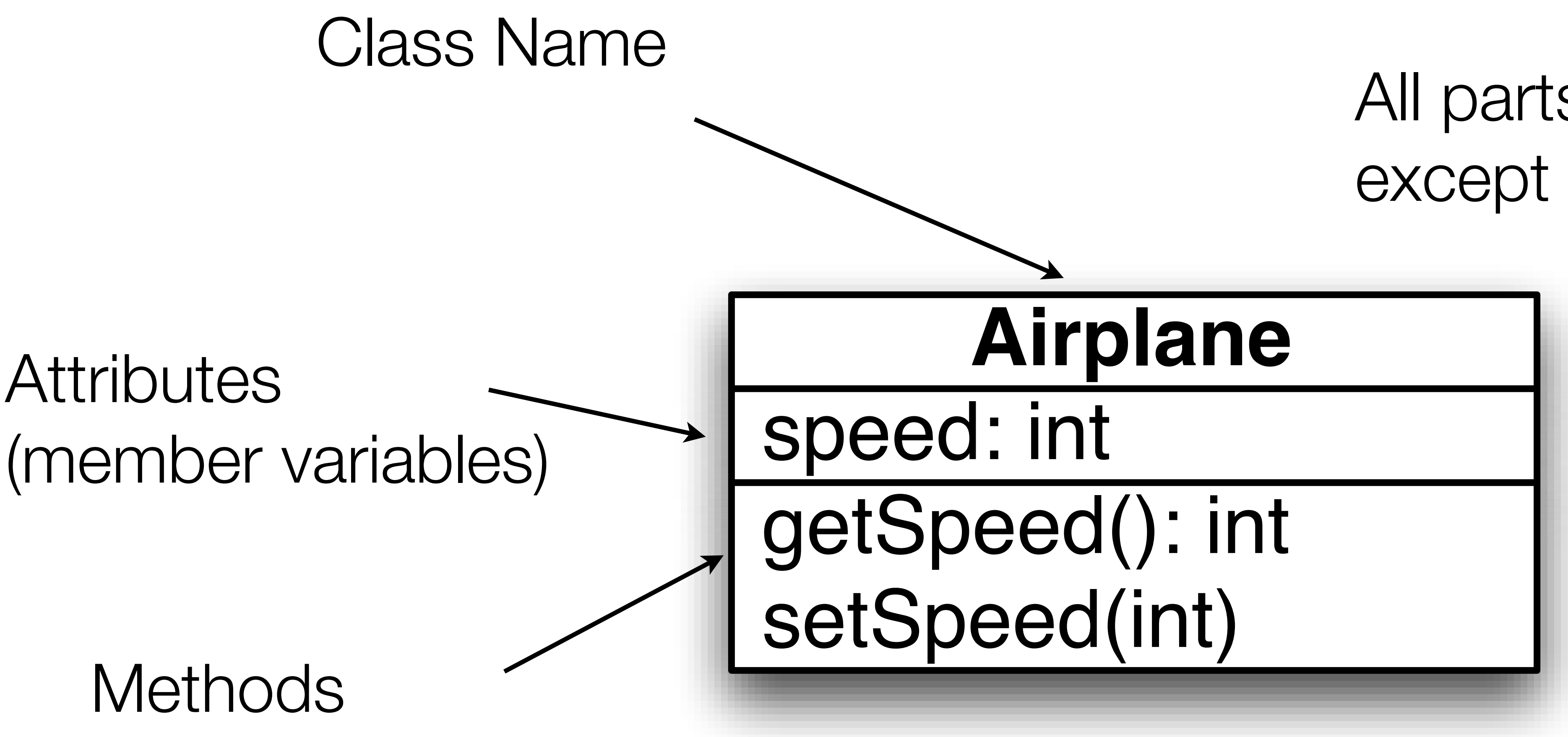
Welcome to Objectville

- What were the major concepts discussed in Appendix II of the textbook?
    - Unified Modeling Language (UML)
    - Class Diagrams
    - Inheritance
    - Polymorphism
    - Encapsulation

UML

- UML stands for **Unified Modeling Language**
  - UML defines a standard set of **notations** for use in **modeling** object-oriented systems
  - Throughout the semester we will encounter UML in the form of
    - class diagrams
    - sequence/collaboration diagrams
    - state diagrams
    - activity diagrams, use case diagrams, and more

Class Diagrams



All parts are optional except the class name

A class is represented as a rectangle

This rectangle says that there is a class called Airplane that could potentially have many instances, each with its own speed variable and methods to access it

Translation to Code

- Class diagrams can be translated into code in a fairly straightforward manner
  - Define the class with the specified name
  - Define specified attributes (assume **private access**)
  - Define specified method skeletons (assume **public**)
- May have to deal with unspecified information
  - Types are optional in class diagrams
  - Class diagrams typically do not specify **constructors**
    - constructors are used to **initialize** an object

Airplane in Java

```java
public class Airplane {

    private int speed;

    public Airplane(int speed) {
        this.speed = speed;
    }

    public int getSpeed() {
        return speed;
    }

    public void setSpeed(int speed) {
        this.speed = speed;
    }

}
```

Airplane in Python

```python
class Airplane(object):

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

    def getSpeed(self):
        return self.speed;

    def setSpeed(self, speed):
        self.speed = speed
```

Airplane in Ruby

```
class Airplane

    attr_accessor :speed

    def initialize(speed)
        @speed = speed
    end

end
```

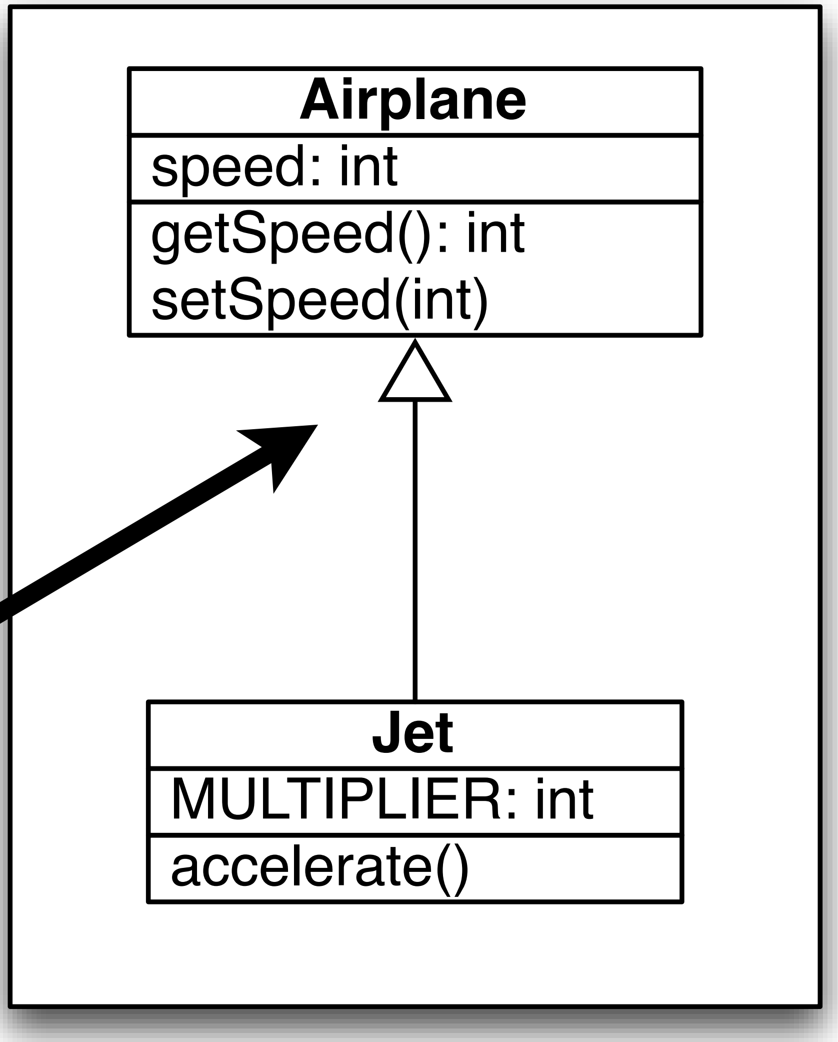
Using these Classes?

- The materials for this lecture contains source code that shows how to use these classes
  - Demonstration
    - **Airplane.java, Airplane.py, Airplane.rb**
- Be sure to attempt to run these examples on your own
  - It will be good experience to learn how to run Java, Python, and Ruby programs on your personal machine or on a Lab machine (either ITS or CSEL)

Inheritance

- Inheritance refers to the ability of one class to **inherit behavior** from another class
  - and change that behavior if needed

Inheritance lets you build classes based on other classes and avoid duplicating and repeating code



Note: UML notation to indicate inheritance is a line between two classes with a triangle pointing at the **base class** or **superclass**

Inheriting From Airplane (in Java)

```
public class Jet extends Airplane {

    private static final int MULTIPLIER = 2;

    public Jet(int id, int speed) {
        super(id, speed);
    }

    public void setSpeed(int speed) {
        super.setSpeed(speed * MULTIPLIER);
    }

    public void accelerate() {
        super.setSpeed(getSpeed() * 2);
    }

}
```

Note:

extends keyword indicates inheritance

super() and **super** keyword is used to refer to superclass

No need to define getSpeed() method; its inherited!

setSpeed() method **overrides** behavior of setSpeed() in Airplane

subclass **can define new behaviors**, such as accelerate()

Inheritance in Python

```
class Jet(Airplane):

    MULTIPLIER = 2

    def __init__(self, id, speed):
        super(Jet, self).__init__(id, speed)

    def setSpeed(self, speed):
        super(Jet, self).setSpeed(speed * Jet.MULTIPLIER)

    def accelerate(self):
        super(Jet, self).setSpeed(self.getSpeed() * 2);
```

Inheritance in Ruby

```ruby
class Jet < Airplane

    @@MULTIPLIER = 2

    def initialize(id, speed)
        super(id, speed)
    end

    def speed=(speed)
        super(speed * @@MULTIPLIER)
    end

    def accelerate()
        @speed = @speed * 2
    end

end
```

Polymorphism: “Many Forms”

- From the textbook: “When one class inherits from another, then polymorphism allows a **subclass** to **stand in** for the **superclass.**”
- Implication: both of these are legal statements
  - Airplane plane = new Airplane()
  - Airplane plane = new Jet()
- Any code that uses the “plane” variable will treat it as an Airplane… this provides flexibility, since that code will run unchanged, **indeed it doesn’t even need to be recompiled**, when new Airplane subclasses are created

Encapsulation

- Encapsulation is
  - when you hide parts of your data from the rest of your application
  - and limit the ability for other parts of your code to access that data
- Encapsulation lets you protect information in your objects from being used incorrectly

- Closely Related Concept: Abstraction
  - What **features** does a class provide to its users?
  - What services can it perform?
  - Indeed, abstraction is the MOST IMPORTANT concern in OO A&D!!

Encapsulation Example

- The “speed” instance variable is private in Airplane. That means that Jet doesn’t have direct access to it.
- Nor does any client of Airplane or Jet objects
- Imagine if we changed speed’s visibility to public
- The encapsulation of Jet’s setSpeed() method would be destroyed

```
Airplane

...
public void setSpeed(int speed) {
    this.speed = speed;
}
...

Jet

...
public void setSpeed(int speed) {
    super.setSpeed(speed * MULTIPLIER);
}
...
```

Demonstration

Summary

- OO software is a **system of communicating objects**
- UML provides **standard notations** for **documenting the structure** of OO systems
- Classes define the **features** of objects, both their **data** and **behavior**
- Inheritance allows classes to **share behavior** and **avoid duplicating/ repeating** code
- Polymorphism allows a **subclass** to **stand in** for its **superclass**
- Encapsulation occurs **when you hide parts of your code** from other parts, **thereby protecting it**

Quick Exercise

- Develop a UML class diagram for the following two classes
  - A Person class that stores a person's name, age, and favorite color
  - An Employee class that stores a person's job title and salary
- Create the diagram such that the following Java code fragment would have a chance at running:
  - Employee e = new Employee("Ken", 41, "blue", "Associate Professor", 0);
  - System.out.println("" + e.getAge());
  - Person p = ….
  - Employe e = new Employee(p, "prof", 0);

Ken’s Corner (I)

- Forgot to mention <http://slashdot.org/> on Tuesday
    - Developer-Oriented discussion forum with the motto:
        - News for Nerds. Stuff that Matters.

- Today’s subject: Python Generators
    - Imagine you have been asked to create a function that produces a sequence of numbers, say the Fibonacci sequence
    - You might decide to take a parameter of the number of values to generate in the sequence and then return the values in a list

Ken’s Corner (II)

```
def fib_list(n):
    results = []
    a, b = 0, 1
    for i in range(n):
        results.append(b)
        a, b = b, a+b
    return results
fib_list(5) returns
    [1, 1, 2, 3, 5]
```

Ken’s Corner (III)

- This approach works great as long as you don’t pass in an unreasonable number for n
  - Why?
- Consider needing to process each element of this sequence, if you did this
- list = fib_list(some_huge_number)
- for i in list:
  - <do something>
- You need to essentially process the list twice:
  - first creating it and then looping over it
  - if it’s a really big list then you also can run into memory-related problems

Ken’s Corner (IV)

- To get around this problem, python added a feature called generators which are functions that contain at least one use of the “yield” keyword
  - When a generator encounters a yield, it saves all the values of its local variables and then returns the value specified by the yield keyword’s expression
  - The next time the generator is called, execution begins just after the statement that contained the yield keyword, with all local variables restored to their previous value

Ken's Corner (IV)

```
def fib(n):
    count = 0
    a, b = 0, 1
    while count < n:
        yield b
        count += 1
        a, b = b, a+b
```

This produces the first n numbers in the Fibonacci sequence, one value at a time. When you call fib(100), you get back an iterator that can be used to loop over the values in the sequence. You can either put the generator directly into a for loop or you can call the generator's next() function to get the next value of the sequence.

Ken's Corner (V)

```
for i in fib(100):
    print(i)
```

- The above will print the first 100 values of the Fibonacci sequence
- Note that this solves the problem on slide 23
  - You can now loop over and process the sequence at the same time
    - You don't have to create a potentially huge list of numbers and then loop over it
- So generators are an excellent way of producing (possibly infinite) sequences in an efficient manner
- Generators can be used in lots of different ways including when implementing state machines, parsers, and looping over large data sets

Ken’s Corner (VI)

- You don’t need to use the fib_list() style of code to create lists either
  - Instead, you can hand a generator to the “list constructor” and it will create a list from the generator
    - In this case, you do have to be aware of memory constraints
- results = list(fib(20))
- print(results)
  - would produce
  - [1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610, 987, 1597, 2584, 4181, 6765]

Coming Up Next

- Lecture 3: Object Fundamentals Continued
  - No reading assignment
  - Note: Lecture 3 **will repeat** some of the things mentioned in this lecture
- Lecture 4: Great Software
  - Read Chapter 1 of the OO A&D book