CSc 110, Spring 2017

Lecture 36: Inheritance

Adapted from slides by Marty Stepp and Stuart Reges

I STARTED A TASK FORCE TO ELIMINATE REDUNDANCIES IN OUR INTERNAL PROCESSES.
REALLY? I'M DOING THE SAME THING.
Dilbert.com DilbertCartoonist@gmail.com
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Review

```
# A class to represent employees.
class Employee:
    def get_hours(self):
        return 40
    def get_salary(self):
        return 40000.0
    def get_vacation_days(self):
        return 10
    def get_vacation_form(self):
        return "yellow"

# A class to represent secretaries.
class Secretary (Employee):

    def take_dictation(self, text):
        print("Taking dictation of text: " + text)
```

How many methods does Employee have?

How many attributes does Employee have?

What's the relationship between Secretary and Employee?

How many methods does Secretary have?

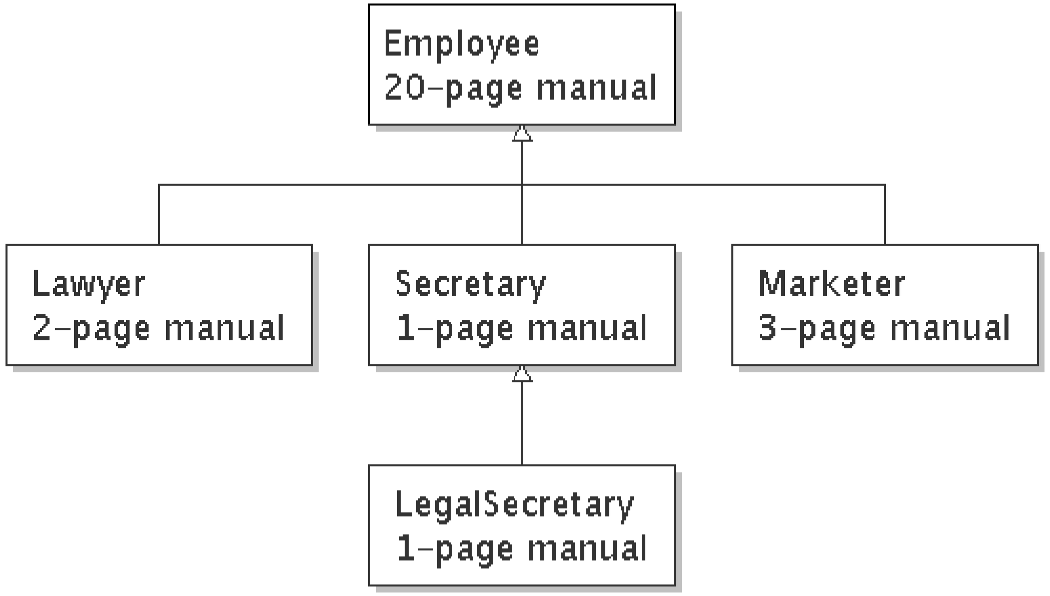
An ___________ is an ____________ of a class.

Terminology

- Superclass
- Subclass

______ is a subclass of __________

______ is a superclass of _________



This is a Unified Modeling Language (UML) class diagram.

Employee regulations

- Consider the following employee regulations:
    - Employees work 40 hours / week.
    - Employees make $40,000 per year, except legal secretaries who make $5,000 extra per year ($45,000 total), and marketers who make $10,000 extra per year ($50,000 total).
    - Employees have 2 weeks of paid vacation leave per year, except lawyers who get an extra week (a total of 3).
    - Employees should use a yellow form to apply for leave, except for lawyers who use a pink form.

- Each type of employee has some unique behavior:
    - Lawyers know how to sue.
    - Marketers know how to advertise.
    - Secretaries know how to take dictation.
    - Legal secretaries know how to prepare legal documents.

Implementing `Lawyer`

- Consider the following lawyer regulations:
  - Lawyers get an extra week of paid vacation (a total of 3).
  - Lawyers use a pink form when applying for vacation leave.
  - Lawyers have some unique behavior: they know how to sue.

- Problem: We want lawyers to inherit *most* behavior from employee, but we want to replace parts with new behavior.

Overriding methods

- **override**: To write a new version of a method in a subclass that replaces the superclass's version.
  - No special syntax required to override a superclass method.
    Just write a new version of it in the subclass.

```
class Lawyer(Employee):
    # overrides get_vacation_form method in Employee
class
    def get_vacation_form():
        return "pink"
    ...
```

- Exercise: Complete the `Lawyer` class.
  - (3 weeks vacation, pink vacation form, can sue)

Lawyer class

```
# A class to represent lawyers.
class Lawyer(Employee):
    # overrides get_vacation_form from Employee class
    def get_vacation_form(self):
        return "pink"

    # overrides get_vacation_days from Employee class
    def get_vacation_days(self):
        return 15           # 3 weeks vacation

    def sue(self):
        print("I'll see you in court!")
```

Exercise: implement `Marketer`

- Recall the following marketer regulations:
  - Marketers make $10,000 more ($50,000 per year)
  - Marketers know how to market. (Print a phrase a marketer might use.)

- Write the code for the `Marketer` class

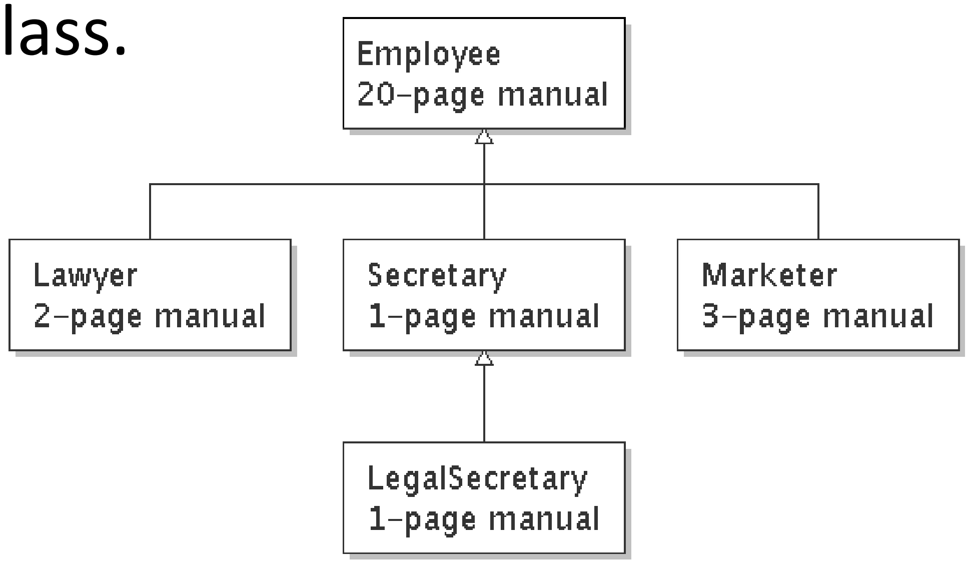
Marketer class

```
# A class to represent marketers.
class Marketer(Employee):
    def advertise(self):
        print("Act now while supplies last!")

    def get_salary(self):
        return 50000.0      # $50,000.00 / year
```

Levels of inheritance

- Multiple levels of inheritance are allowed.
  - Example: A legal secretary is the same as a regular secretary but makes more money ($45,000) and can file legal briefs
- Exercise: Complete the `LegalSecretary` class.



LegalSecretary class

```
# A class to represent legal secretaries.
class LegalSecretary(Secretary):
    def file_legal_briefs(self):
        print("I could file all day!")

    def get_salary(self):
        return 45000.0      # $45,000.00 / year
```

Change of perspective

- Recall the regulations regarding salaries:
    - Employees make $40,000 per year, except legal secretaries who make $5,000 extra per year ($45,000 total), and marketers who make $10,000 extra per year ($50,000 total).

- We've been hardcoding the salaries in the methods like this:

```
def get_salary(self):
    return 45000.0          # $45,000.00 / year
```

- Instead, consider writing the methods in terms of a base salary plus an "uplift" :

```
class LegalSecretary(Secretary):
    def get_salary(self):
        base_salary = ...regular employee salary...
        return base_salary + 5000.0
    ...
```

Calling overridden methods

- Subclasses can call overridden methods with `super`

  `super(`**ClassName**`, self).`**method**`(`**parameters**`)`

  - Example:

```
class LegalSecretary(Secretary):
    def get_salary(self):
        base_salary = super(LegalSecretary,self).get_salary()
        return base_salary + 5000.0
    ...
```

Inheritance and constructors

- Imagine that we want to give employees more vacation days the longer they've been with the company.
  - For each year worked, we'll award 2 additional vacation days.
  - When an Employee object is constructed, we'll pass in the number of years the person has been with the company.
  - This will require us to modify our `Employee` class and add some new state and behavior.
  - Exercise: Make necessary modifications to the `Employee` class.

Modified `Employee` class

```
class Employee:
    def __init__(self, initial_years):
        self.__years = initial_years

    def get_hours(self):
        return 40

    def get_salary(self):
        return 50000.0

    def get_vacation_days(self):
        return 10 + 2 * self.__years

    def get_vacation_form(self):
        return "yellow"
```

Problem with constructors

- Now that we've added the constructor to the `Employee` class, an error is produced:

```
TypeError: __init__() missing 1 required positional
  argument: 'initial_years'
```

  - Short explanation: Once we write an `__init__(self, p1, … pn)` that requires parameters in the superclass, we must now write initialization methods for our employee subclasses as well.

  - Exception: If the default behavior of the superclass is acceptable for all subclasses, you simply modify the class construction expression.

Modified `Marketer` class

```
# A class to represent marketers.
class Marketer(Employee):
    def __init__(years):
        super(Marketer, self).__init__(years)

    def advertise(self):
        print("Act now while supplies last!")

    def get_salary():
        return super(Marketer, self).get_salary() + 10000.0
```

- Exercise: Modify the `Secretary` subclass.
  - Secretaries' years of employment are not tracked.
  - They do not earn extra vacation for years worked.

Modified `Secretary` class

```
# A class to represent secretaries.
class Secretary(Employee):
    def __init__(self):
        super(Secretary, self).__init__(0)

    def take_dictation(self, text):
        print("Taking dictation of text: " + text)
```

- Since `Secretary` doesn't require any parameters to its constructor, `LegalSecretary` does not require a constructor.
  - Its default constructor calls the `Secretary` constructor.

Inheritance and attributes

- Try to give lawyers $5000 for each year at the company:

```
class Lawyer(Employee):
    ...
    def get_salary(self):
        return super(Lawyer, self).get_salary() + 5000 *
 self.__years
    ...
```

- Does not work; the error is the following:

```
AttributeError: 'Lawyer' object has no attribute
  '_Lawyer__years'                                      ^
```

- Private attributes cannot be directly accessed from subclasses.
  - One reason: So that subclassing can't break encapsulation.
  - How can we get around this limitation?

Improved `Employee` code

Add an accessor for any attribute needed by the subclass.

```
class Employee:
    self.__years

    def __init__(self, initial_years):
        self.__years = initial_years

    def get_years(self):
        return self.__years
    ...

class Lawyer(Employee):
    def __init__(self, years):
        super(Lawyer, self).__init__(years)

    def get_salary(self):
        return super(Lawyer, self).get_salary() + 5000 *
  get_years()
    ...
```

Revisiting `Secretary`

- The `Secretary` class currently has a poor solution.
  - We set all Secretaries to 0 years because they do not get a vacation bonus for their service.
  - If we call `get_years` on a `Secretary` object, we'll always get 0.
  - This isn't a good solution; what if we wanted to give some other reward to *all* employees based on years of service?

- Redesign our `Employee` class to allow for a better solution.

Improved `Employee` code

- Let's separate the standard 10 vacation days from those that are awarded based on seniority.

```
class Employee:
    def __init__(self, initial_years):
        self.__years = initial_years

    def get_vacation_days(self):
        return 10 + self.get_seniority_bonus()

    # vacation days given for each year in the company
    def get_seniority_bonus(self):
        return 2 * self.__years
    ...
```

- How does this help us improve the `Secretary`?

Improved `Secretary` code

- `Secretary` can selectively override `get_seniority_bonus`; when `get_vacation_days` runs, it will use the new version.
  - Choosing a method at runtime is called *dynamic binding*.

```
class Secretary(Employee):
    def __init__(self, years):
        super(Secretary, self).__init__(years)

    # Secretaries don't get a bonus for their years of service.
    def get_seniority_bonus(self):
        return 0

    def take_dictation(self, text):
        print("Taking dictation of text: " + text)
```