

Object Oriented Programming

Objectives

- To review the concepts and terminology of object-oriented programming
- To discuss some features of object-oriented design

Review: Revisit the Person Class

```
public class Person{  
    /* Attribute declarations */  
    private String lastName;  
    private String firstName;  
    private String email;
```

- Variables lastName, firstName, and email are reference variables, i.e. they can store addresses of objects (in this case objects of the class String)
- They have not been assigned a value (we say that they have not been initialized)

Review: Constructors

- A **constructor** is a special *method* that is called automatically when an object is created with the **new** operator
 - Its purpose is to *initialize the attributes* of an object when the object is created
 - In Python we use the special method `__init__` to do the job of a constructor
 - In Java a constructor has the same name as the class name

Example: Person class

```
/**
 * Constructor initializes the person's name
 *          and email address
 */
public Person(String firstName, String lastName, String email) {
    this.lastName = lastName;
    this.firstName = firstName;
    this.email = email;
}
```

Compared to Python, in Java one must EXPLICITLY give types to the attributes. Also note the difference between the keyword *this* vs Python's *self*.

Review: Terminology

- Keyword *this* similar to *self* in Python
- **Scope of variables**
 - **Scope** refers to the parts of the code in which those variables can be used
 - Scope of instance variables?
- **Formal parameters**
 - What is their scope?

Example: Person Class

- What *methods* might we want to have?
 - *accessor methods* (aka *getters*)
 - *modifier methods* (aka *setters*)
 - *toString* method (in Python this is `__repr__` or `__str__`)
 - *equals* method (in Python this is `__eq__`)
 - two Person objects are the same if they have the same first name and same last name

Example: Person class

Java

```
/**
 * setEmail method sets the person's
 *   email address
 * @param email
 */
public void setEmail (String email) {
    this.email = email;
}
```

Python

```
"""
setEmail method sets the person's
email address.
:param email: email address to set
"""
def setEmail(self,email):
    self.email=email
```

Note that Python uses WHITESPACE to tie blocks of code together Java uses BRACES and SEMICOLONS (you should still code with whitespace as well)

What is this @param?

- [Javadoc documentation](#) (we will do it in Lab 2)

Example: Person class

Python

```
def __repr__(self):  
    s = self.firstName + " " + self.lastName + "\t" + self.email  
    return s
```

Java

```
/**  
 * toString method returns a string representation of the person  
 * @return string with first name and last name, email address  
 */  
public String toString() {  
  
    String s = this.firstName + " " + this.lastName + "\t" + this.email ;  
    return s;  
}
```

Discussion

- What is the return type of this method?
- What is `t`?
- What kind of variable is `s`?
 - A **reference variable** of type `String`
- What is its scope?
 - It is a **local variable**

Python

```
def equals(self, other):
    if self.firstName == other.getFirstName() and self.lastName == other.getLastName() :
        return True
    else :
        return False
```

Java

```
/**
 * equals determines whether two persons have the same name
 * @param other    other Person object that this is compared to
 * @return true if they have the same first and last name, false otherwise
 */
public boolean equals(Person other) {
    if (this.firstName.equals(other.firstName) && this.lastName.equals(other.lastName))
        return true;
    else
        return false;
}
```

- What is `this.firstName`? `other.firstName`?
- Where is the `equals` method that is used in the code?

Example: SocialNetwork Class

- We are now ready to provide a class that allows us to keep track of our social contacts
- What attributes might it have?
 - A list of **Person** objects
 - We'll use an **array** as our **data structure** (*this is similar to the notation of a list in Python*)
 - A count of the number of friends currently in the list
 - Why is this not necessarily the same as the size of the array?

Example: SocialNetwork Class

Python:

```
from Person import Person
class SocialNetwork:
    def __init__(self,num=0):
        self.friends =[]
        self.numFriends =num
```

Java:

```
/* Attribute declarations */
// array of persons (list of friends)
private Person[] friendList;

//current number of friends in list
private int numFriends;
/* Constant definition */
private final int DEFAULT_MAX_FRIENDS = 10;
```

Notice in Python we declare the attributes in the constructor itself

Review: Terminology

- Keyword *final* (no such thing in Python, by convention we used all capitalized words to represent a constant)
- Array declaration `[]` (array's and python lists do NOT always act the same)

Example: SocialNetwork Class

- **Constructors:**
 - One that creates an array of default size
 - One that takes the size of the array as a parameter
- What do we call it when there is more than one constructor?
 - ***overloading***
 - ***In Python we do this by setting defaults in the method***

Python:

```
from Person import Person
class SocialNetwork:
    def __init__(self,num=0):
        self.friends =[]
        self.numFriends =num
```

Notice how there is only one constructor for Python but it uses default values to allow for different uses of it.

Also note than in Java arrays must **MUST** have an specified size; lists can grow dynamically in Python.

Java:

```
/**
 * Constructor creates Person array of default size
 */
public SocialNetwork () {
    friendList = new Person[DEFAULT_MAX_FRIENDS];
    numFriends = 0;
}

/**
 * Constructor creates Person array of specified size
 * @param max      maximum size of array
 */
public SocialNetwork(int max) {
    friendList = new Person[max];
    numFriends = 0;
}
```

Discussion

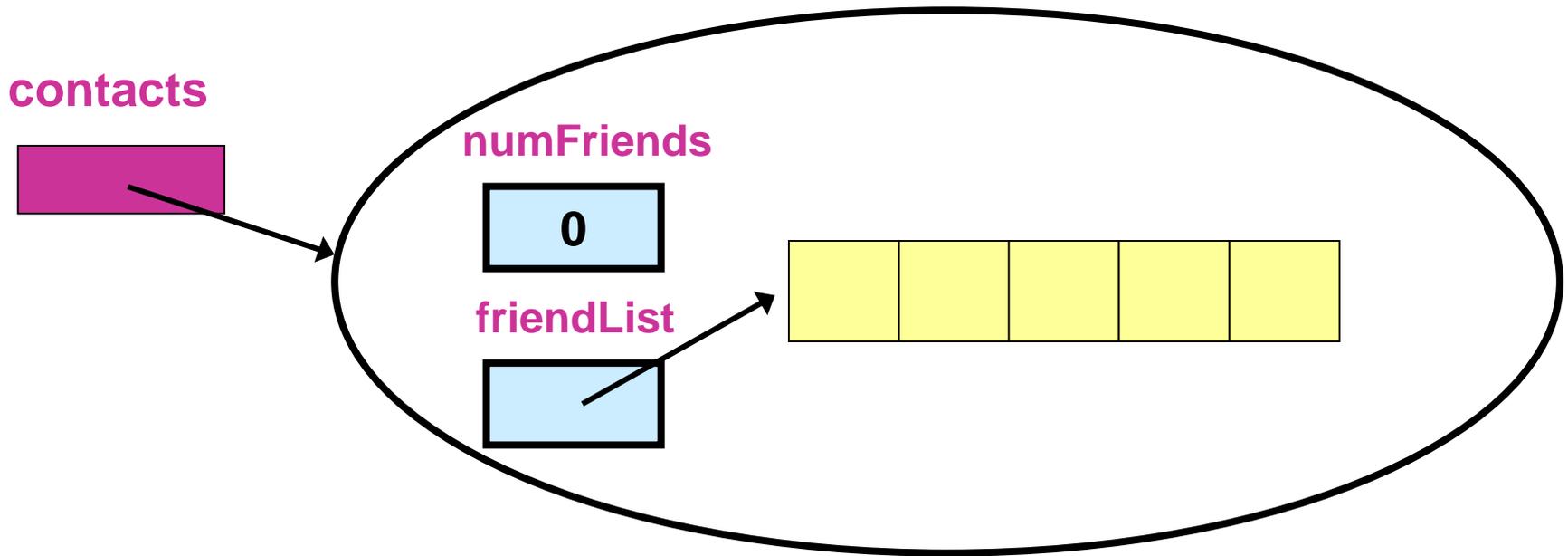
- What is stored in the `friendList` array after the following is executed?

```
friendList = new Person[DEFAULT_MAX_FRIENDS];
```

- How does this differ from Python?
`self.friends = []`

Example: SocialNetwork Object

```
contacts = new SocialNetwork(5);
```



Example: SocialNetwork Class

- **Instance methods:** let's start with methods to
 - add a person to the list
 - remove a specified person from the list
 - clear the list, i.e. remove all persons
 - return how many persons are in the list
 - **toString**
- *(we will add other methods later)*

```
Python:
def add(aFriend):
    self.friends.append(aFriend)
    self.numFriends = len(self.friends)
```

Add method

```
Java:
/**
 * add method adds a person to the list
 * @param firstName
 * @param lastName
 * @param email
 */
public void add (Person friend) {

    // add it to the array of friends // but, what if array is not big enough?
    // double its capacity automatically

    if (numFriends == friendList.length)
        expandCapacity();

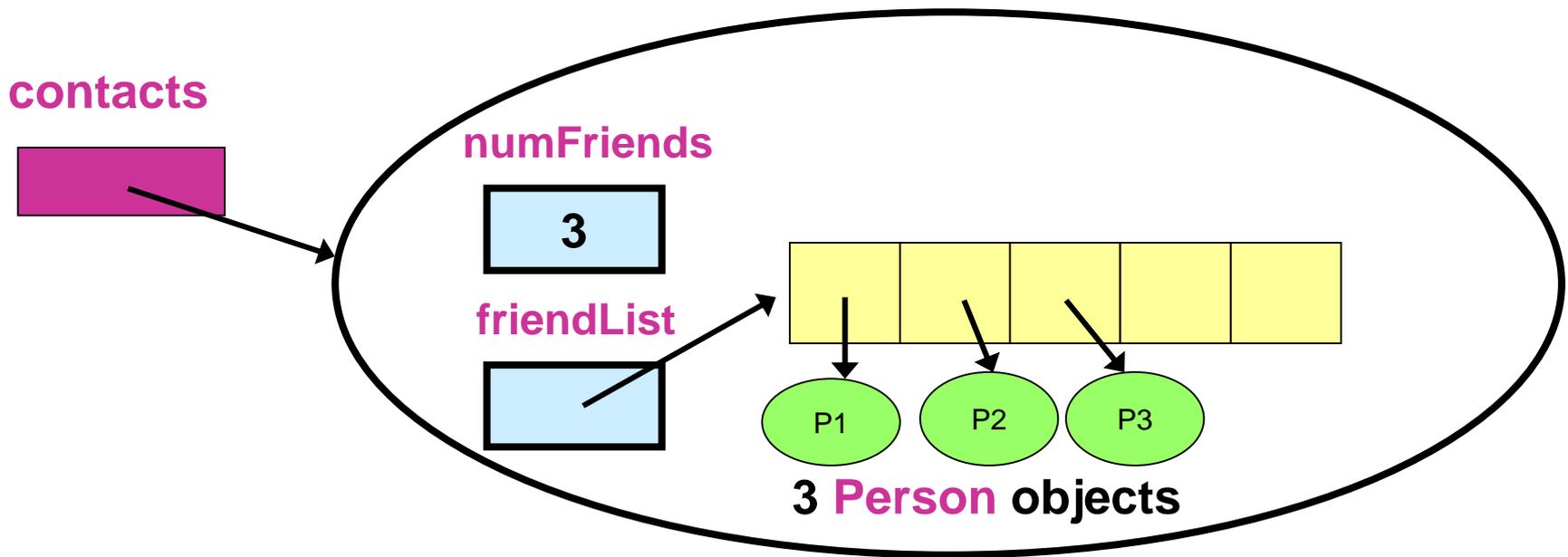
    // add reference to friend at first free spot in array

    friendList [numFriends] = friend;
    numFriends++;
}
```

Example: SocialNetwork Object

`contacts = new SocialNetwork(5);`

After 3 friends are added it will look like this:



Note that `numFriends` also acts as the index of the first free spot in the array!

Review: Arrays

- An array has a particular number of cells when it is created (its **capacity**)
- What happens when an array is full and we try to store past the last element in the array?
 - An **exception** is thrown
 - What happens then?
- We can instead *automatically expand the capacity* of the array in our code!

```
/**
 * expandCapacity method is a helper method
 * that creates a new array to store friends, with twice
 * the capacity of the existing one
 */
private void expandCapacity() {

    Person[] largerList = new Person[friendList.length * 2];

    for (int i = 0; i < friendList.length; i++)
        largerList [i] = friendList [i];

    friendList = largerList;
}
```

Note in Python we did not have to do this as lists can grow dynamically

Review: Terminology

- Helper method
- Array **length**
- **Scope of variables**: what is the scope of each of the following variables?
 - **friendList**
 - **largerList**
 - **i**

Python

```
def __repr__(self):
    s = ""
    for element in self.friends:
        s = s + "\n" + element.getFriend()
    return s
```

toString

Java

```
/**
 * toString method returns a string representation of all persons in the list
 * @return string representation of list
 */
public String toString() {
    String s = "";
    for (int i = 0; i < this.numFriends; i++){
        s = s + friendList[i].toString() + "\n" ;
    }
    return s;
}
```

- What is "" ? "\n" ?

Class `SocialNetwork` contains a method for removing a data item from the array. To remove a data item, say *target*, from the array we first need to find the position of such an item in the array. A simple way of looking for *target* in array *friendList* is to take the data items stored in the array one by one starting at the data item stored in index 0 and compare each one of them with *target* until either

- *target* is found, or
- all data items have been examined and *target* is not found

The above algorithm for looking for a data item in a list is called *linear search*.

Once item *target* has been found in the array we can remove it by replacing it with the last item in the array. **Pseudocode** for removing a data item from the array follows.

Algorithm `remove(target)`

Input: data item to be removed

Output: true if *target* was removed from the array; false
if *target* was not found in the array

`i = 0`

while (`i < numFriends`) **and** (`friendList[i]` not equal *target*) **do**
 `i = i+1`

if `i = numFriends` **then return** *false*

else {

`friendList[i] = friendList[numFriends-1]`

`friendList[numFriends-1] = null`

`numFriends = numFriends - 1`

return *true*

}

The advantage of writing an algorithm in **pseudocode** is that we can concentrate on designing the steps that the algorithm needs to perform to achieve the desired task without having to think about how to express the algorithm in correct java syntax.

Once we have designed a correct algorithm for a problem in pseudocode, translating it into java is a somewhat mechanical process.

Writing algorithms in pseudocode and then translating them into java makes it easier to design programs.

The beauty of pseudocode is that there is no fixed syntax or rigid rules for it. Pseudocode is a mixture of English and programming-like statements.

Each programmer comes up with their own version of pseudocode. The programmer just needs to ensure that pseudocode is understandable to other people and that it is detailed enough that translation into java or other programming language is simple. There should be an (almost) one-to-one correspondence between lines of pseudocode and lines of java.

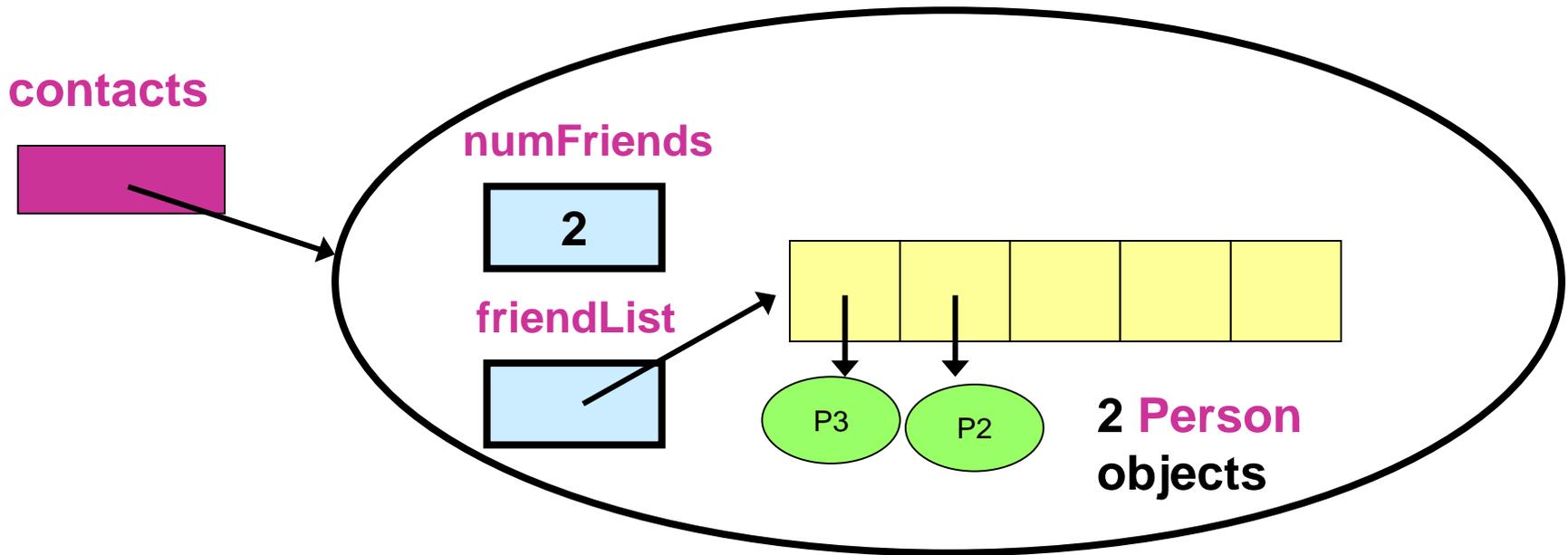
The java version for the remove algorithm follows.

```
public boolean remove(Person target) {
    // search the list for the specified friend
    int i = 0;
    while ((i < numFriends) && !friendList[i].equals(target))
        i++;

    if (i == numFriends) return false;
    else {
        // person found, remove by replacing with last one
        friendList[i] = friendList[numFriends - 1];
        friendList[numFriends - 1] = null;
        numFriends--;
        return true;
    }
}
```

Example: SocialNetwork Object

Suppose the target person to be removed was the first one (P1) ; after it is removed, we will have:



Discussion

- The search in the `remove` method is called a ***linear search***
 - It starts at the beginning and continues in a sequential manner
- Where is the `equals` method of the line `friendList [i].equals(target)` defined?

Discussion

- Why is it OK to replace the reference to the found Person with the last one in the list?

Exercises

- Write `getNumFriends`
- Write `clearFriends`

Example: Using the SocialNetwork Class

Python:

```
def main():
    from SocialNetwork import SocialNetwork
    from Person import Person

    contacts = SocialNetwork();
    contacts.add("Snoopy", "Dog", "snoopy@uwo.ca");
    contacts.add("Felix", "Cat", "felix@uwo.ca");
    contacts.add("Mickey", "Mouse", "mickey@uwo.ca");
    print(contacts)
    print("I have " + contacts.getNumFriends() + " friends in my contact list")

main()
```

Java:

```
public class MyFriends {
    public static void main (String args[]) {

        SocialNetwork contacts = new SocialNetwork();

        contacts.add("Snoopy", "Dog", "snoopy@uwo.ca");
        contacts.add("Felix", "Cat", "felix@uwo.ca");
        contacts.add("Mickey", "Mouse", "mickey@uwo.ca");

        System.out.println(contacts.toString());
        System.out.println("I have " + contacts.getNumFriends() +
            " friends in my contact list."); }
}
```

Discussion

- Note that if we had
`System.out.println(contacts);`
then Java would automatically invoke the `toString` method of the class that `contacts` belongs to
- How many friends could you add to your list of friends, in an application program that uses our `SocialNetwork` class?

The second line in the above java class:

```
public static void main (String[] args) {
```

states that method `main`, when invoked can receive any number of arguments. Java will create an array, called `args`, of the correct size to store the arguments. Java was designed so that the first method that is executed in any java program is `main`. The arguments that are passed to this method are called the *program arguments* or *command line arguments*.

The keyword `static` tells the java compiler that when the program is executed a special object, called a *static object*, needs to be created. Static objects are different from other objects in that they are not created by the programmer with the `new` statement. Since to run a java program, objects need to be created first, this solves the issue of how to create the very first object of a program.

Exercise: Expand the SocialNetwork Class

- The **SocialNetwork** class could use some more methods in order to be useful!
 - A method that writes the list to a file
 - A method that reads the list from a file
 - A method that searches for a particular friend in the list, and returns the email address

Review: Passing Parameters

- Why are methods written with **parameter lists**?
 - So that the methods can be more general
 - We can use methods with *different values* passed in as parameters

Review: Passing Parameters

- How are parameters actually passed?
- The variable in the parameter list in the *method definition* is known as a ***formal parameter***
- When we *invoke a method* with a parameter, that is known as an ***actual parameter***

Passing Parameters: How it Works

```
public class MyFriends {  
  {  
    public static void main(String[] args)  
    { ...  
      contacts.add("Felix", "Cat",  
                  "felix@uwo.ca");  
      ....  
    }  
  }  
}
```

```
public class SocialNetwork {  
  ...  
  public void add (String firstName, String  
                  lastName, String email) {  
    ...  
  }  
}
```

actual parameters

are provided by the calling program when it **invokes** the method

formal parameters

are part of the **method definition**

When the `add` method is executed, the value of each actual parameter is ***passed by value*** to the corresponding formal parameter variable

Aspects of Object-Oriented Design

- Modularity
- Information Hiding
- Encapsulation

Aspects of Program Design: Modularity

- **Modularity** refers to subdividing a large problem into smaller components, or **modules**, to make the design of a solution easier
 - Modules should be as independent from each other as possible
 - Each module should perform one well-defined task

Aspects of Program Design: Information Hiding

- ***Information hiding*** refers to making implementation details inaccessible
 - To users of a program (they do not need to know about implementation details)
 - To other modules in a program (they cannot see nor change the *hidden* details)
 - Example: **attributes (instance variables)** in a class definition are ***private***
 - What parts of a program can access instance variables directly?

Aspects of OOP Design: Encapsulation

- ***Object-oriented Design*** produces modular solutions
- We identify the components involved within the problem: the ***objects***
 - An object has data: ***characteristics (attributes)***, and ***behaviours (operations)***
- Combining the *data* and the *operations on the data* is called ***encapsulation***
 - They are combined in the class definition