Object Oriented Programming

Objectives

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

Review: Objects

- In Java and other Object-Oriented Programming (OOP) languages, the focus is on ***objects***
- ***Objects*** are entities that can do actions or be acted upon in a Java program
- All objects have
  - ***Properties***
    - These are the *data* about an object
    - In Java we call them ***attributes*** or ***fields*** or ***instance variables***
  - ***Behaviours*** (***actions***)
    - In Java they are implemented as ***methods*** (more specifically, ***instance methods***)

Review: Objects and Classes

- Every object belongs to a specific ***class***
  - Objects that belong to the same class have the same properties and can perform the same actions
- We can think of a class as being a ***template*** or ***pattern*** or ***model*** or ***definition*** for objects of that class

Review: Object-Oriented Programming

- ***Object-oriented programs*** consist of ***interacting objects***
  - Objects are ***defined by*** classes
  - Objects are ***created by*** objects of other classes (***client classes***) which ***use*** them in implementing a programming solution to a problem

Example: Social Networking

- Suppose we want to keep track of social contact information for our friends / relatives
- We wish to write a program that allows us to add contact information of a friend to our list of friends, remove a contact from the list, and print information about all our contacts.

Software Development Life Cycle

The process of designing a computer program has several steps:

- Specification
- Design
- Implementation
- Testing and debugging
- Maintenance

Example: Social Networking

- Part of OOP design is deciding on what classes we will need for our problem
- Let's start with a class called Person, that will model the information about one person in our social network

Review: Class Definition

- A ***class definition*** consists of
  - Attribute declarations
    (also known as fields or instance variables)
  - Constructor definitions
  - Method definitions
- A class definition is stored in a file
  - With the same name as the class
  - With a .java extension on the file

Example: Person Class

- ***Attributes (instance variables, fields)***
  - What kind of information do we want to have about a person? Let’s keep it short for now
    - Person's name
    - Email address
  - What type should each of these be?
    - A name can be a string
    - An email address can be a string

Example Python: Person Class

```
class Person:

        def __init__(self, firstName=“”, lastName,=“” email=“”):
            self.firstName = firstName
            self.lastName = lastName
            self.email = email
```

- Note in Python we can assign default values to the attributes in this case we used an empty string

Example Java: Person Class

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

- Why are the attributes private?
- Note that the instance variables are just being ***declared*** here (not explicitly assigned values)

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're 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?

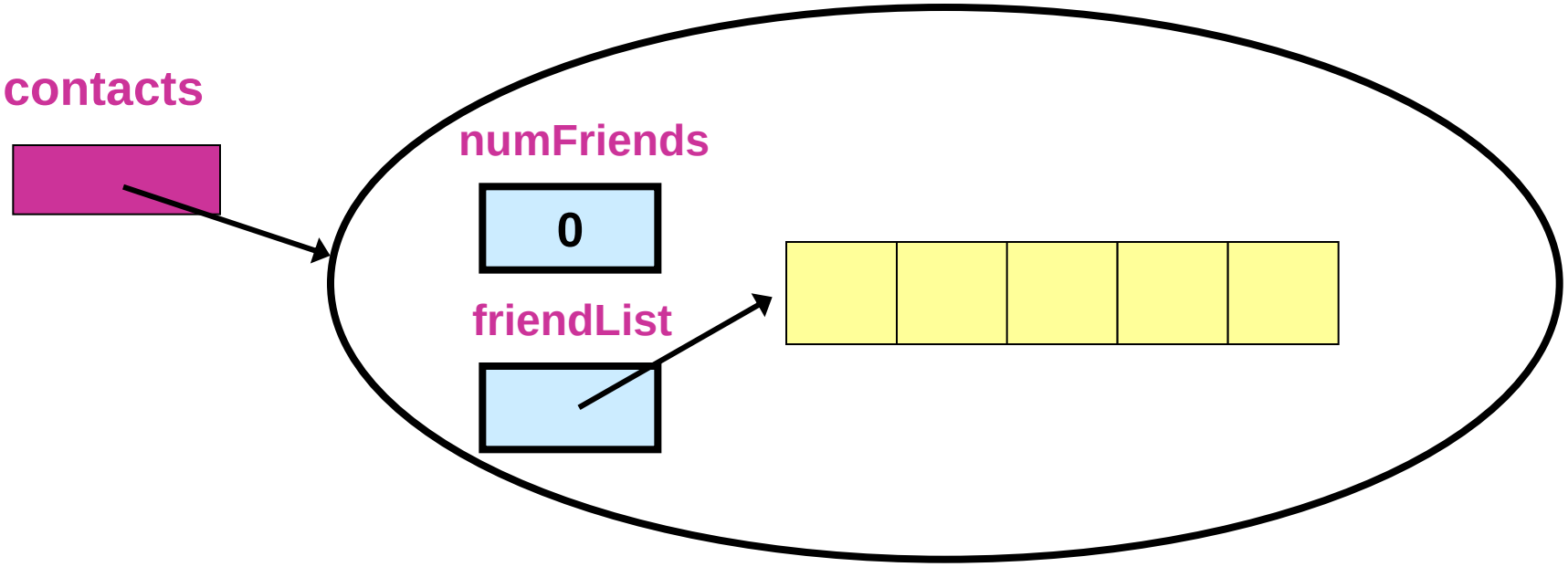
  friendList = new Person[DEFAULT_MAX_FRIENDS];

- 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)*

Add method

Python:

```
def add(self, first, last, email):
    aFriend = Person(first,last,email)
    self.friends.append(aFriend)
    self.numFriends = len(self.friends)
```

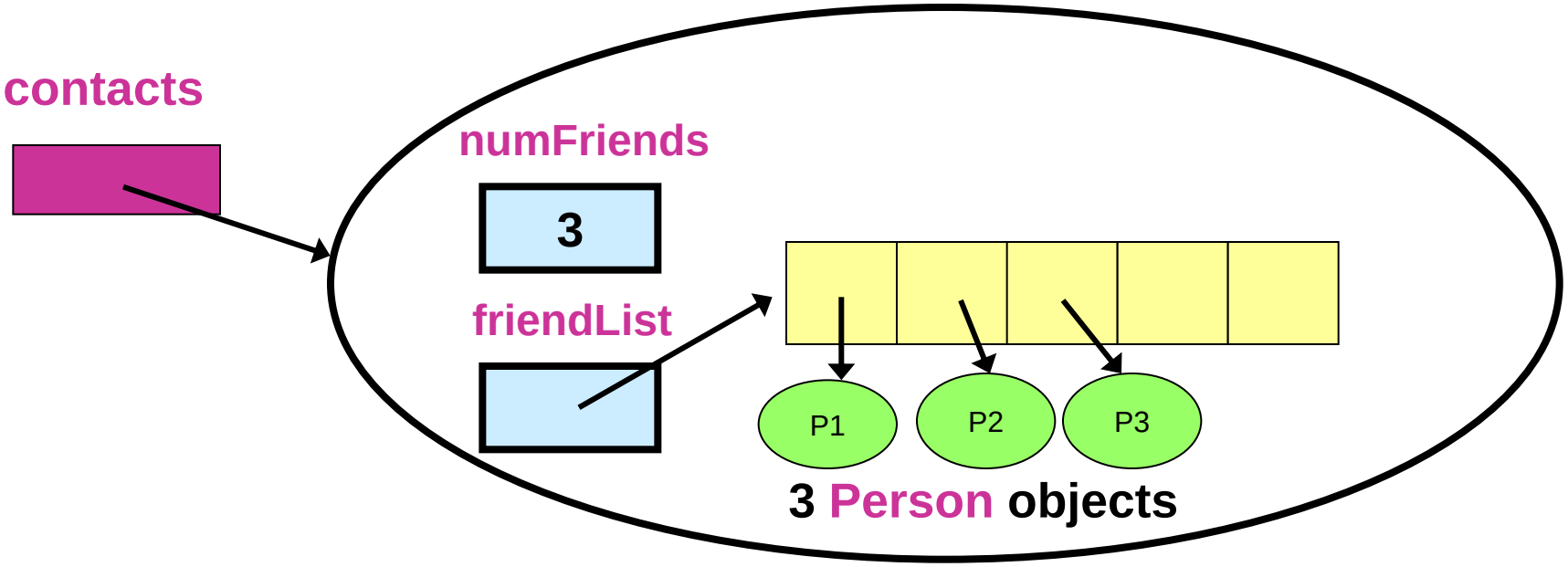
Java:

```
/**
* add method adds a person to the list
* @param firstName
* @param lastName
* @param email
*/
public void add (String firstName, String lastName, String email) {

        // create a new Person object
        Person friend = new Person (firstName, lastName, email);

        // 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" ?

Python:

```
def remove(self, first, last):
        i = -1
        for element in self.friends:
            if element.getFirstName() == first and element.getLastName() == last:
                i = self.friends.index(element)
        if i > -1:
            self.friends.pop(i)
            self.numFriends = len(self.friends)
            return True
        else:
            return False
```

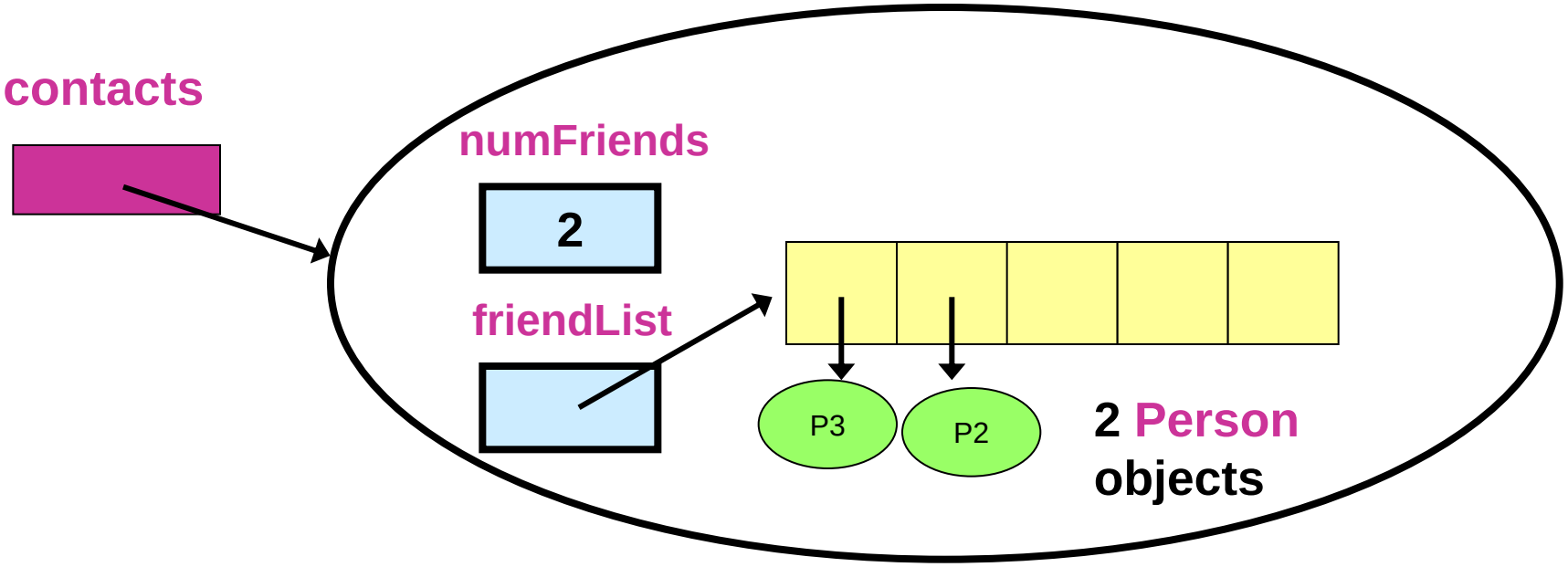
remove method

Java:

```
/**
* remove method removes a specified friend from the list
* @param firstName       first name of person to be removed
* @param lastName       last name of person to be removed
* @return true if friend was removed successfully, false otherwise
*/
public boolean remove (String firstName, String lastName) {
    final int NOT_FOUND = -1;
    int search = NOT_FOUND;
    Person target = new Person(firstName, lastName, "");

    // if list is empty, can't remove
    if (numFriends == 0)
            return false;
    // search the list for the specified friend
    for (int i = 0; i < numFriends &&
                                search == NOT_FOUND; i ++)
            if (friendList [i].equals(target))
                            search = i;
    // if not found, can't remove
    if (search == NOT_FOUND)
            return false;

    // target person found, remove by replacing with
    // last one in list

            friendList[search] = 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
- Why have we used a constant definition here, and why is it -1?

```
final int NOT_FOUND = -1;
```

- Where is the equals method of the line

```
if (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?

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
  - Others?

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