Lecture 05:Bags

CS 0445: Data Structures

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http://db.cs.pitt.edu/courses/cs0445/current.term/

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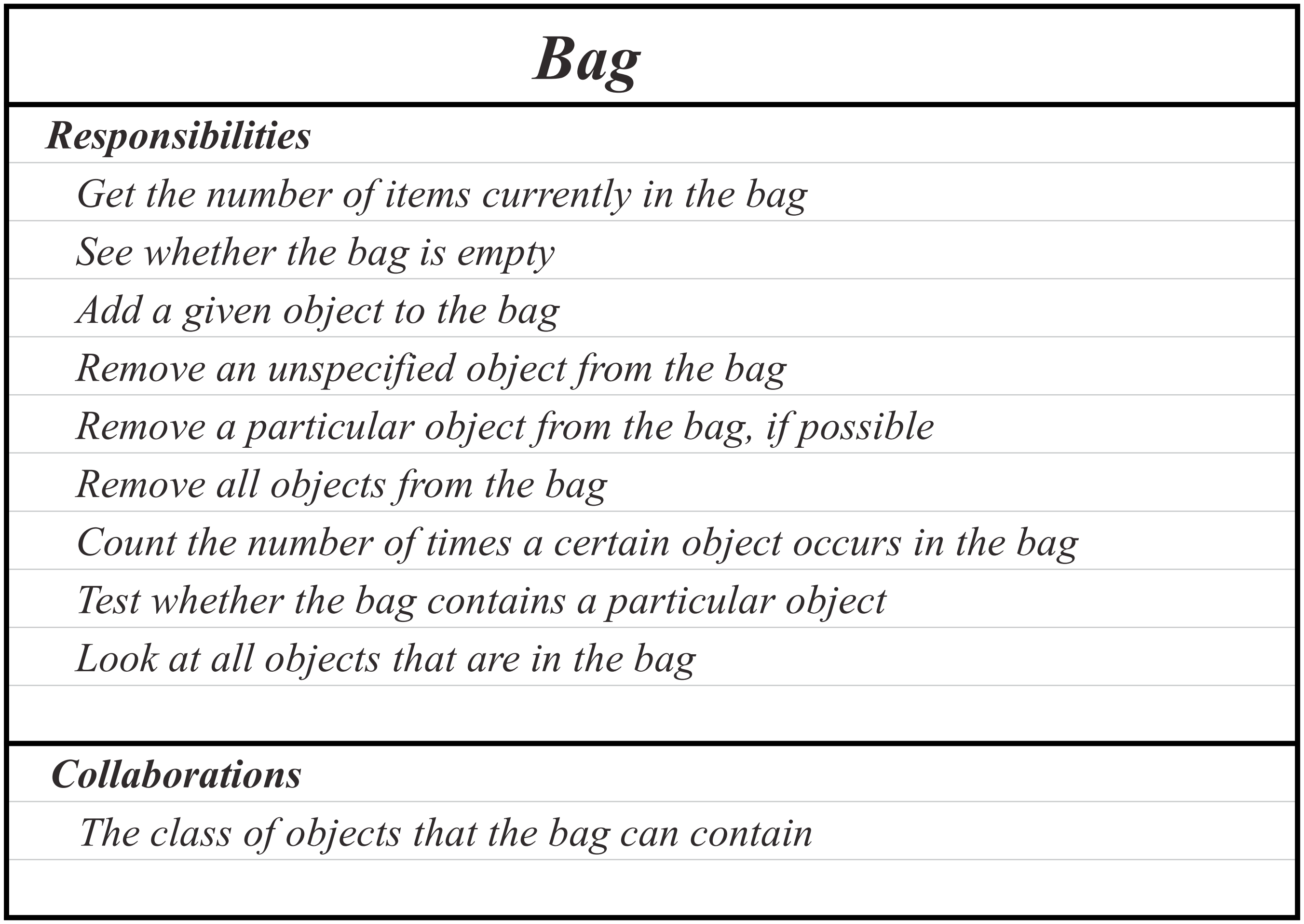
What Is an Iterator?

- An object that traverses a collection of data
- During iteration, each data item is considered once
  - Possible to modify item as accessed
- Should implement as a distinct class that interacts with the ADT

The ADT Bag

- Definition
  - A finite collection of objects in no particular order
  - Can contain duplicate items
- Possible behaviors
  - Get number of items
  - Check for empty
  - Add, remove objects

CRC Card



Bag

Responsibilities

Get the number of items currently in the bag

See whether the bag is empty

Add a given object to the bag

Remove an unspecified object from the bag

Remove a particular object from the bag, if possible

Remove all objects from the bag

Count the number of times a certain object occurs in the bag

Test whether the bag contains a particular object

Look at all objects that are in the bag

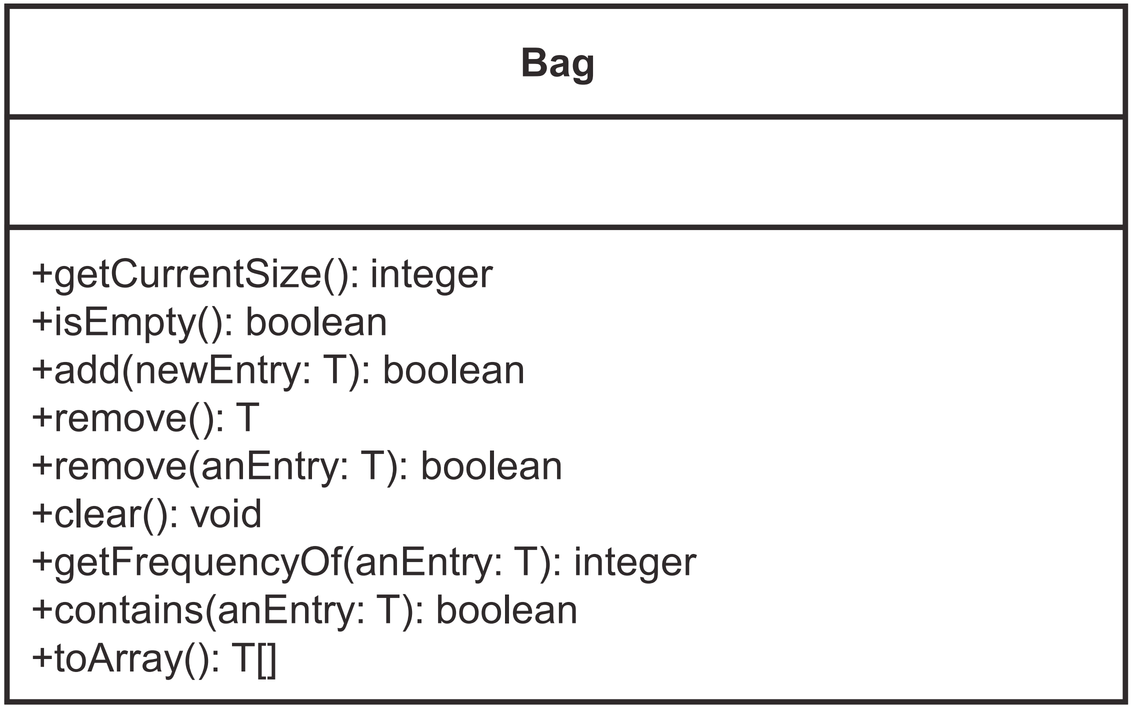
Collaborations

The class of objects that the bag can contain

Specifying a Bag

- Describe its data and specify in detail the methods
- Options that we can take when add cannot complete its task:
  - Do nothing
  - Leave bag unchanged, but signal client
- Note which methods change the object or do not

Using UML Notation to Specify a Class



Bag

+getCurrentSize(): integer
+isEmpty(): boolean
+add(newEntry: T): boolean
+remove(): T
+remove(anEntry: T): boolean
+clear(): void
+getFrequencyOf(anEntry: T): integer
+contains(anEntry: T): boolean
+toArray(): T[]

Design Decision

- What to do for unusual conditions?
- Assume it won’t happen
- Ignore invalid situations
- Guess at the client’s intention
- Return value that signals a problem
- Return a boolean
- Throw an exception

An Interface (Part 1)

```
/** An interface that describes the operations of a bag of objects. */
public interface BagInterface<T>
{
    /** Gets the current number of entries in this bag.
     @return  The integer number of entries currently in the bag. */
    public int getCurrentSize();

    /** Sees whether this bag is empty.
     @return  True if the bag is empty, or false if not. */
    public boolean isEmpty();

    /** Adds a new entry to this bag.
       @param newEntry  The object to be added as a new entry.
       @return  True if the addition is successful, or false if not. */
    public boolean add(T newEntry);

    /** Removes one unspecified entry from this bag, if possible.
   @return  Either the removed entry, if the removal.
          was successful, or null. */
    public T remove();
```

An Interface (Part 2)

```
 /** Removes one occurrence of a given entry from this bag, if possible.
@param anEntry  The entry to be removed.
@return  True if the removal was successful, or false if not. */
 public boolean remove(T anEntry);

 /** Removes all entries from this bag. */
 public void clear();

 /** Counts the number of times a given entry appears in this bag.
  @param anEntry  The entry to be counted.
  @return  The number of times anEntry appears in the bag. */
 public int getFrequencyOf(T anEntry);

 /** Tests whether this bag contains a given entry.
  @param anEntry  The entry to find.
  @return  True if the bag contains anEntry, or false if not. */
 public boolean contains(T anEntry);

 /** Retrieves all entries that are in this bag.
  @return  A newly allocated array of all the entries in the bag.
        Note: If the bag is empty, the returned array is empty. */
 public T[] toArray();
} // end BagInterface
```

Using the ADT Bag

```java
/** A class that maintains a shopping cart for an online store. */
public class OnlineShopper
{
      public static void main(String[] args)
      {
    Item[] items = {new Item("Bird feeder", 2050),
                    new Item("Squirrel guard", 1547),
                    new Item("Bird bath", 4499),
                    new Item("Sunflower seeds", 1295)};

    BagInterface<Item> shoppingCart = new Bag<>();
    int totalCost = 0;
   // Statements that add selected items to the shopping cart:
    for (int index = 0; index < items.length; index++)
    {
      Item nextItem = items[index]; // Simulate getting item from shopper
      shoppingCart.add(nextItem);
      totalCost = totalCost + nextItem.getPrice();
    } // end for

    // Simulate checkout
    while (!shoppingCart.isEmpty())
           System.out.println(shoppingCart.remove());

      System.out.println("Total cost: " + "\t$" + totalCost / 100 + "." +
                 totalCost % 100);
      } // end main
} // end OnlineShopper
```

Program Output

```
Sunflower seeds $12.95
Bird bath      $44.99
Squirrel guard     $15.47
Bird feeder        $20.50
Total cost:     $93.91
```

Example: A Piggy Bank

```
/** A class that implements a piggy bank by using a bag. */
public class PiggyBank
{
    private BagInterface<Coin> coins;

    public PiggyBank()
    {
    coins = new ArrayBag<>();
    } // end default constructor

    public boolean add(Coin aCoin)
    {
    return coins.add(aCoin);
    } // end add

    public Coin remove()
    {
    return coins.remove();
    } // end remove

    public boolean isEmpty()
    {
    return coins.isEmpty();
    } // end isEmpty
} // end PiggyBank
```

Example: Using A Piggy Bank (Part 1)

```
/** A class that demonstrates the class PiggyBank. */
public class PiggyBankExample
{
    public static void main(String[] args)
    {
    PiggyBank myBank = new PiggyBank();

    addCoin(new Coin(1, 2010), myBank);
    addCoin(new Coin(5, 2011), myBank);
    addCoin(new Coin(10, 2000), myBank);
    addCoin(new Coin(25, 2012), myBank);

    System.out.println("Removing all the coins:");
   int amountRemoved = 0;

   while (!myBank.isEmpty())
   {
     Coin removedCoin = myBank.remove();
     System.out.println("Removed a " + removedCoin.getCoinName() + ".");
     amountRemoved = amountRemoved + removedCoin.getValue();
   } // end while

    System.out.println("All done. Removed " + amountRemoved + " cents.");
    } // end main
```

Example: Using A Piggy Bank (Part 2)

```
    private static void addCoin(Coin aCoin, PiggyBank aBank)
    {
    if (aBank.add(aCoin))
        System.out.println("Added a " + aCoin.getCoinName() + ".");
    else
        System.out.println("Tried to add a " + aCoin.getCoinName() +
                           ", but couldn't");
    } // end addCoin
} // end PiggyBankExample
```

Program Output

```
Added a PENNY.
Added a NICKEL.
Added a DIME.
Added a QUARTER.
Removing all the coins:
Removed a QUARTER.
Removed a DIME.
Removed a NICKEL.
Removed a PENNY.
All done. Removed 41 cents.
```

Observations about Vending Machines

- Can perform only tasks machine’s interface presents.
- You must understand these tasks
- Cannot access the inside of the machine
- You can use the machine even though you do not know what happens inside.
- Usable even with new insides.

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A vending machine

Observations about ADT Bag

- Can perform only tasks specific to ADT
- Must adhere to the specifications of the operations of ADT
- Cannot access data inside ADT without ADT operations
- Use the ADT, even if don’t know how data is stored
- Usable even with new implementation.

Java Class Library: The Interface `Set`

```java
/** An interface that describes the operations of a set of objects. */
public interface SetInterface<T>
{
    public int getCurrentSize();
    public boolean isEmpty();

    /** Adds a new entry to this set, avoiding duplicates.
      @param newEntry  The object to be added as a new entry.
      @return  True if the addition is successful, or
        false if the item already is in the set. */
    public boolean add(T newEntry);

    /** Removes a specific entry from this set, if possible.
   @param anEntry  The entry to be removed.
   @return  True if the removal was successful, or false if not. */
    public boolean remove(T anEntry);

    public T remove();
    public void clear();
    public boolean contains(T anEntry);
    public T[] toArray();
} // end SetInterface
```

Generic Data Types

- Enable you to write a placeholder instead of an actual class type
- The placeholder is
  - A generic data type
  - A type parameter
- You define a generic class
  - Client chooses data type of the objects in collection.

Interface

The interface `Pairable`

```
/**
   An interface for pairs of objects.
*/
public interface Pairable<T>
{
  public T getFirst();
  public T getSecond();
  public void changeOrder();
} // end Pairable
```

Example Generic Class (Part 1)

The class OrderedPair

```
/** A class of ordered pairs of objects having the same data type. */
public class OrderedPair<T> implements Pairable<T>
{
  private T first, second;

  public OrderedPair(T firstItem, T secondItem)
          // NOTE: no <T> after constructor name
  {
    first = firstItem;
    second = secondItem;
  } // end constructor

  /** Returns the first object in this pair. */
  public T getFirst()
  {
    return first;
  } // end getFirst
```

Example Generic Class (Part 2)

The class OrderedPair

```
  /** Returns the second object in this pair. */
  public T getSecond()
  {
    return second;
  } // end getSecond

  /** Returns a string representation of this pair. */
  public String toString()
  {
    return "(" + first + ", " + second + ")";
  } // end toString

  /** Interchanges the objects in this pair. */
  public void changeOrder()
  {
    T temp = first;
    first = second;
    second = temp;
  } // changeOrder
} // end OrderedPair
```