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Java Programming

3-3
Collections – Part 2

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Overview

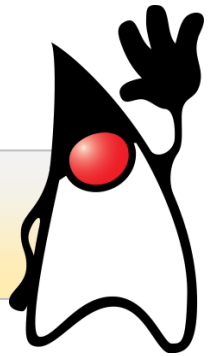
This lesson covers the following topics:

- Implement a HashMap
- Implement a stack by using a deque
- Define a linked list
- Define a queue
- Implement a Comparable interface

Collections

- We have seen previously that we can use ArrayLists and HashSets to store multiple data.
- Java has a rich library of collections that will handle a varied list of requirements.

Understanding what collections are available and what they offer makes it easier to select the most relevant one.



Maps

- A map is a collection that links a key to a value.
- Similar to how an array links an index to a value, a map links a key (one object) to a value (another object).
- Maps, like sets, cannot contain duplicates.
- This means each key can only exist once and can only link to a single value.
- Since Map is an interface, you must use one of the classes that implement Map such as HashMap to instantiate a map.

HashMaps

- HashMaps are maps that link a Key to a Value.
- The Key and Value can be of any type, but their types must be consistent for every element in the HashMap.
- The KeyType and the ValueType can be the same or different types.
- HashMaps, like sets contain no order. They do allow one null for the key, and multiple nulls for the value.

HashMap Methods

Method	Method Description
`boolean containsKey(Object Key)`	Returns true if the HashMap contains the specified Key.
`boolean containsValue(Object Value)`	Returns true if this map maps one or more keys to the specified value.
`V get(Object key)`	Returns the value to which the specified key is mapped, or null if this map contains no mapping for the key.
`Set<K> keySet()`	Returns a set of the keys contained in the HashMap.
`Collection<V> values()`	Returns a collection of the values contained in the HashMap.
`V remove(Object Key)`	Removes the mapping for the specified key from this map if present.
`int size()`	Returns the number of key-value mappings in the HashMap.

More methods can be found in the Java API

HashMaps Example

- This is a generic breakdown of how to initialize a HashMap.

```
HashMap<KeyType,ValueType> mapName = new HashMap<KeyType,ValueType>();
```

- If a program is required to group together and store many different fruits as well as their colors then a HashMap is an ideal Collection to implement.




HashMaps Example

1. Create a project named hashsetexample.
2. Create a HashMapExample class that includes a main method.
3. Initialize a HashMap named fruitBowl that will hold 2 String values.

```
import java.util.HashMap;

public class HashMapExample {

   public static void main(String[] args) {
      HashMap<String,String> fruitBowl = new HashMap<String, String>();

   }//end method main
}//end class HashMapExample
```

Add Fruits to fruitBowl Example

4. Create an AddElements method that accepts the HashMap as a parameter and add an apple using the put(Key,Value) function of the HashMap collection:

```
    public static void main(String[] args) {
        HashMap<String,String> fruitBowl = new HashMap<String, String>();

        addElements(fruitBowl);
    }//end method main

    static void addElements(HashMap<String, String> fruitBowl) {
        fruitBowl.put("Apple", "Green");
    }//end method addElements

}//end class HashMapExample
```

5. Add the following fruits to the fruitBowl.

Add Fruits to fruitBowl Example


```
   static void addElements(HashMap<String, String> fruitBowl) {
      fruitBowl.put("Apple", "Green");
      fruitBowl.put("Cherry", "Red");
      fruitBowl.put("Orange", "Orange");
      fruitBowl.put("Banana", "Yellow");
}//end method addElements
}//end class HashMapExample
```

6. Create a displayElements method that accepts the HashMap as a parameter and will be used to display the values of the HashMap.

```
   displayElements(fruitBowl);
}//end method main

static void displayElements(HashMap<String, String> fruitBowl) {

}//end method displayElements
```

Add Fruits to fruitBowl Example

7. To simply check the contents of the HashMap you can include its name in an output statement.

```
static void displayElements(HashMap<String, String> fruitBowl) {
   System.out.println(fruitBowl);
}//end method displayElements
```

- This will produce the following output:

```
{Apple=Green, Cherry=Red,
Orange=Orange, Banana=Yellow}
```

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Add Fruits to fruitBowl Example

8. To format the output to suit your need you can use an enhanced for loop.

```
static void displayElements(HashMap<String, String> fruitBowl) {
   //System.out.println(fruitBowl);
   for (HashMap.Entry<String, String> fruit : fruitBowl.entrySet())
   {
      System.out.println("Fruit: " + fruit.getKey()
                         +" - Color: "+fruit.getValue());
   }//endfor
}//end method displayElements
```

- This uses the entrySet() method that returns a set of the map that can then be displayed:

```
Fruit: Apple - Color: Green
Fruit: Cherry - Color: Red
Fruit: Orange - Color: Orange
Fruit: Banana - Color: Yellow
```

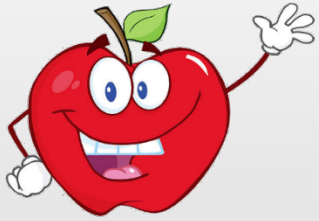
Add Fruits to fruitBowl Example

- Remember that a map like a set cannot contain duplicates. The key and value are uniqueso doing this:
  - `hashmapExample.put(1,"b");`
  - `hashmapExample.put(1,"a");`

  Will override the map 1->b to 1->a

9. Add a red apple to the bottom of the add elements method to see that you lose the green apple.

```
static void addElements(HashMap<String, String> fruitBowl){
   fruitBowl.put("Apple", "Green");
   fruitBowl.put("Cherry", "Red");
   fruitBowl.put("Orange", "Orange");
   fruitBowl.put("Banana", "Yellow");
   fruitBowl.put("Apple", "Red");
}//end method addElements
```



get(Key) Method of HashMap

- The Key of a HashMap can be thought of as the index linked to the element, even though it does not have to be an integer.
- Getting the value stored is easy once it's understand that the key is the index: Use the get(Key) method of the HashMap.
- To get the color of the Banana in the fruit bowl, use this method which searches through the HashMap until it finds a Key match to the parameter ("Banana") and returns the Value for that Key ("Yellow").

```
String bananaColor = fruitBowl.get("Banana");
```

Add Fruits to fruitBowl Example

10. Create the following method that will check if the fruit exists in the bowl and then display its value to screen or else display a fruit not found method..

```
   findElement(fruitBowl, "Banana");
}//end method main

static void findElement(HashMap<String, String> fruitBowl,
                        String fruit) {
   if(fruitBowl.containsKey(fruit))
      System.out.println("The " + fruit + " is "
                         + fruitBowl.get(fruit));
   else
      System.out.println("There is no " + fruit + " in the bowl");
   //endif
}//end method findElement
```

- Test the method by using an existing fruit and a “Pear”.

Maps

- HashMap is just one of many Map collections.
- There are also:
  - Hashtable,
  - EnumMap,
  - IdentityHashMap,
  - LinkedHashMap,
  - Properties,
  - TreeMap,
  - WeakHashMap

LinkedList Methods

- A Queue is a LinkedList that operates a **F**irst **I**n **F**irst **O**ut system known as FIFO.
- Stacks are a LinkedList that operates a **L**ast **I**n **F**irst **O**ut system known as FIFO.

FIFO LinkedList Methods	LIFO LinkedList Methods
`add(E e)` Appends the given element to the end of the list.	**`push(E e)`** Pushes an element onto the stack represented by this list.
`removeFirst()` Removes the first element from the list and returns it.	**`pop()`** Pops an element from the stack represented by this list.
`set(int index, E element)` Replaces the element at the specified position in the list.	**`size()`** Returns the number of elements in this list.

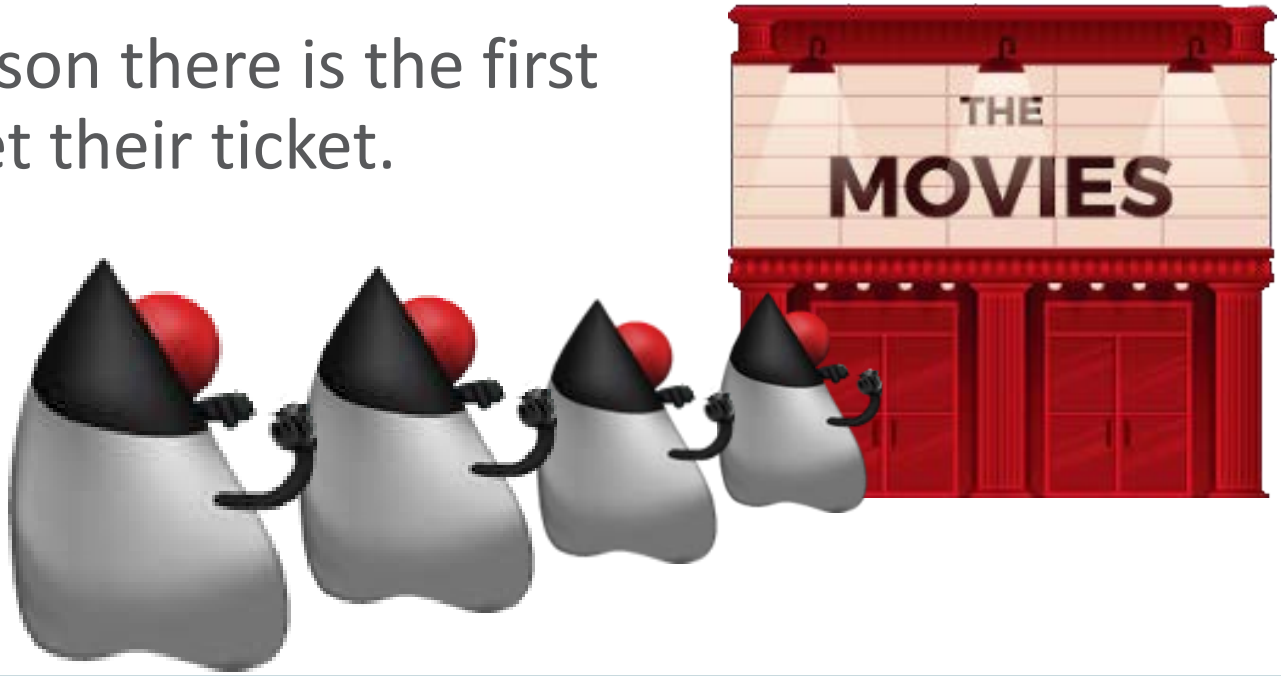
More LinkedList methods can be found in the Java API

LinkedList: Queues

- A Queue is a list of elements with a first in first out ordering (**F**irst **I**n **F**irst **O**ut, also known as FIFO).
- When you enqueue (Add) an element, it adds it to the end of the list.
- When you dequeue (Remove) an element, it returns the element at the front of the list and removes that element from the list.

LinkedList: Queues

- Queues are commonly used when the order of adding an object is important, with the first one added being the first one removed.
- For example, picture a line at the movie theater.
  - The first person there is the first person to get their ticket.



Using a LinkedList as a Queue

A LinkedList is initialized in the same way as ArrayList.

1. Create a project named lettersqueue.
2. Create a class named LettersQ.
3. Initialize a LinkedList of String named lettersQ.

```
import java.util.LinkedList;

public class LettersS {

   public static void main(String[] args) {
      //This will be implemented as a queue
      LinkedList<String> lettersQ = new LinkedList<String>()
```

Using a LinkedList as a Queue

4. Use the add method to add elements to the Stack.

```
//Adding elements to the end of the queue
lettersQ.add("A");
lettersQ.add("B");
lettersQ.add("C");
lettersQ.add("D");
```

5. Display the contents and size of the Queue.

```
//display the contents of the linked list
System.out.println("Linked list : " + lettersQ);
//display the size of the linked list
System.out.println("Queue Size: " + lettersQ.size());
```

Using a LinkedList as a Queue

6. Use a while loop to remove the first element from the Queue and display them to the console while the Queue is not empty. Display the empty Queue after.

```
        //while the Queue is not empty remove each element
        while(!lettersQ.isEmpty()) {
           System.out.println(lettersQ.removeFirst());
        }//endwhile
        //display the contents of the linked list
        System.out.println("Linked list : " + lettersQ);
    }//end method main
}//end class LettersQ
```

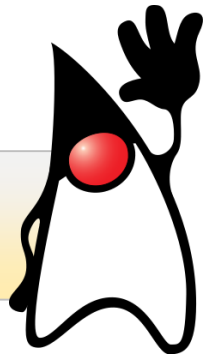
7. Your output should look like this:

```
Linked list : [A, B, C, D]
Queue Size: 4
A
B
C
D
Linked list : []
```

LinkedList: Stacks

- Stacks are Queues that have reverse ordering to the standard Queue.
- Instead of FIFO ordering (like a queue or line at the theater), the ordering of a stack is last in first out.
- This can be represented by the acronym LIFO (**L**ast **I**n **F**irst **O**ut.

The undo method on software typically uses this method where the last action is the one that is used.



Stack of Pancakes Example

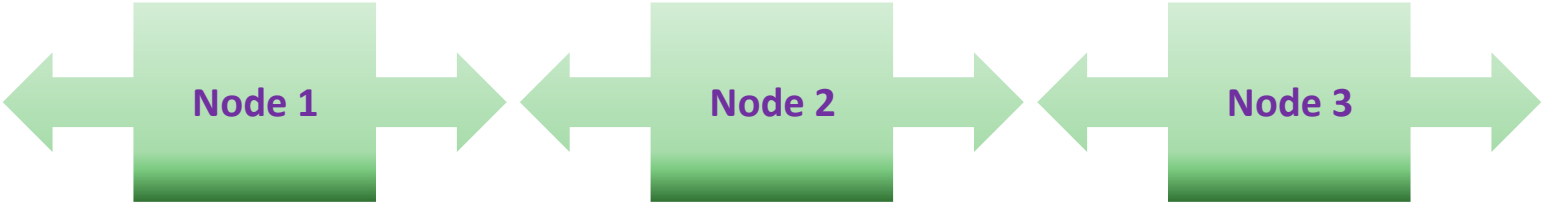
- If there was a pile of pancakes it would be typically called a “stack” of pancakes because the pancakes are added on top of the previous leaving the most recently added pancake at the top of the stack.
- To remove a pancake, you would have to take off the one that was most recently added: The pancake on the top of the stack.
- If you tried to remove the pancake that was added first, you would most likely make a very large mess.

Implementing a Stack: Deque

- One way to implement a Stack is by using a Double-Ended Queue (or deque, pronounced “deck”, for short).
- These allow us to insert and remove elements from either end of the queue using methods inside the Deque class.
- Deques like building blocks, allow you to put pieces on the bottom of your structure or on the top, and likewise pull pieces off from the bottom or top.
- Deques can be implemented by LinkedLists.

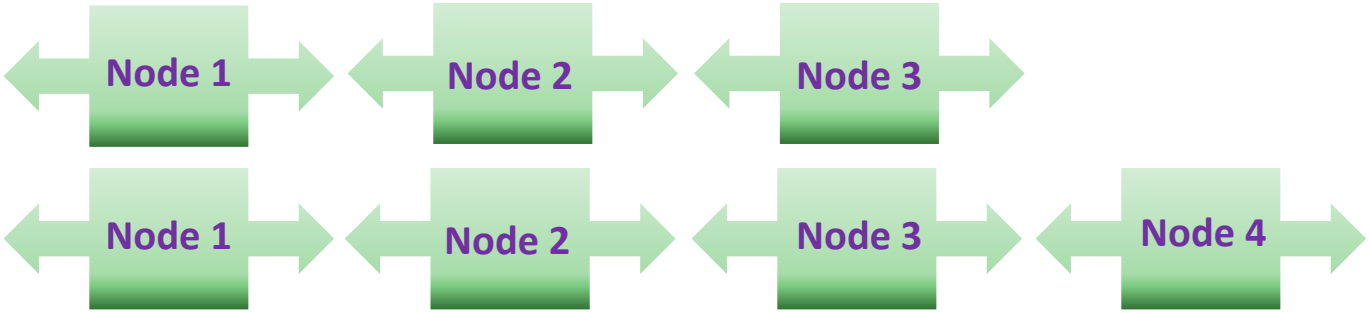
LinkedLists

- A LinkedList is a list of dynamically-stored elements.
- Like an ArrayList, it changes size and has an explicit ordering, but it doesn't use an array to store information.
- It uses an object known as a Node.
- Nodes are like roadmaps: they tell you where you are (the element you are looking at), and where you can go (the previous element and the next element).



Adding Nodes to LinkedLists

- Ultimately, we have a list of Nodes, which point to other Nodes and have an element attached to them.
- To add a Node, set its left Node to the one on its left, and its right Node to the one on its right.
- Do not forget to change the Nodes around it as well.
- A fourth node was added to the end of this linked list:



Using a LinkedList as a Stack

A LinkedList is initialized in the same way as ArrayList.

1. Create a project named lettersstack.
2. Create a class named LettersS.
3. Initialize a LinkedList of String named lettersStack.

```
import java.util.LinkedList;

public class LettersS {

   public static void main(String[] args) {
      //This will be implemented as a stack
      LinkedList<String> letterStack = new LinkedList<String>();
```

Using a LinkedList as a Stack

4. Use the push method to add elements to the Stack.

```
//Adding elements to the top of the stack
letterStack.push("A");
letterStack.push("B");
letterStack.push("C");
letterStack.push("D");
```

5. Display the contents and size of the Stack.

```
//display the contents of the linked list
System.out.println("Linked list : " + letterStack);

//display the size of the linked list
System.out.println("Stack Size: " + letterStack.size());
```

Using a LinkedList as a Stack

6. Use a while loop to remove (pop) elements from the Stack and display them to the console while the Stack is not empty. Display the empty Stack after.

```
        //while the stack is not empty remove each element
        while(!letterStack.isEmpty()) {
            System.out.println(letterStack.pop());
        }//endwhile
        //display the contents of the linked list
        System.out.println("Linked list : " + letterStack);
    }//end method main
}//end class Letters
```

7. Your output should look like this:

```
Linked list : [D, C, B, A]
4
D
C
B
A
Linked list : []
```

Sorting a Collection

- Using the sort method of the Collections class has already been discussed in this course in regards to sorting using simple elements.
- In the classlist example the ArrayList of student names were sorted using the Collections.sort() method as they were stored as Strings.

```
Collections.sort(studentNames);
```

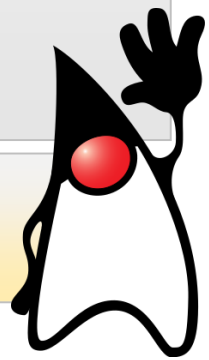
- This sorted the ArrayList in its natural alphabetic order.
- Sort is a static method within the class Collections, so doesn't have to be initialized.

Sorting a Collection

- This is fine with simple elements but what if the students' details had been stored in a class instead of being represented by a String?
- What if there were additional fields, which field should the students be sorted on?

```
public class Student {
   private String firstName;
   private String lastName;
   private int mark;
         .
         .
}//end class Student
```

A class may have many fields, you would have to decide which field to base the sort on!



Sorting a Collection Example

1. Create a classlistobj project.
2. Create a Student class that does not have a main method. It should have the following instance fields and constructor:

```
public class Student {
   private String firstName;
   private String lastName;
   private int mark;

   public Student(String firstName, String lastName, int mark) {
      this.firstName = firstName;
      this.lastName = lastName;
      this.mark = mark;
   }//end constructor
}//end class Student
```

Sorting a Collection Example

3. Create getters and setters for all of the instance fields.

```
    public String getFirstName() {
        return firstName;
    }//end method getFirstName

    public void setFirstName(String firstName) {
        this.firstName = firstName;
    }//end method etFirstName

    public String getLastName() {
        return lastName;
    }//end method getLastName

    public void setLastName(String lastName) {
        this.lastName = lastName;
    }//end method setLastName

    public int getMark() {
        return mark;
    }//end method getMark

    public void setMark(int mark) {
        this.mark = mark;
    }//end method setMark
}//end class Student
```

Sorting a Collection Example

4. Create a toString method that will return the value of the instance fields:

```
public class Student {

        .
        .
        .

 public String toString() {
    return "Student Details: " + firstName
    + " " + lastName + " " + mark;
    }//end method toString
}//end class Student
```

The student class will be updated later in this lesson to allow the sorting of students.

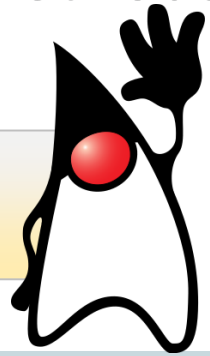
The Comparable Interface

- For the classes to have a natural order the interface java.lang.Comparable can be implemented.

```
public interface Comparable<T> {
  int compareTo(T o);
}//end method main
```

- If the Comparable interface was implemented then the code for compareTo must be included in the class.
- Eclipse will prompt you to add unimplemented methods to help you with this.

The Comparable interface is an excellent example of using interfaces in your design.



compareTo

- The compareTo() method will return an integer based on the following:
  - Return a negative value if this object is smaller than the other object
  - Return 0 (zero) if this object is equal to the other object.
  - Return a positive value if this object is larger than the other object.
- compareTo() expects an integer value to be returned which can be used to determine the ordering of the objects.

Sorting a Collection Example

5. Implement the Comparable interface in the Student class.

```
public class Student implements Comparable<Student> {
```

6. When the Comparable interface is implemented it forces the inclusion of compareTo() method. This will be used for the Collections.sort method.

```
@Override
public int compareTo(Student arg0) {
   if(lastName.compareTo(stud2.getLastName()) < 0 )
      return -1;
   if(lastName.compareTo(stud2.getLastName()) == 0 )
      return 0;
   return 1;
}//end method compareTo
```

Sorts the students based on their last name!

Sorting a Collection Example

7. Create a driver class that will add students and then display them to screen.

```
public class StudentDriver {
   public static void main(String[] args) {
      ArrayList<Student> studentNames = new ArrayList();

      addStudents(studentNames);
      displayStudents(studentNames);
      Collections.sort(studentNames);
      displayStudents(studentNames);
   }//end method main

   static void displayStudents(ArrayList<Student> studentNames) {
      for(Student student: studentNames)
         System.out.println(student);
      //endfor
   }//end method displayStudents
```

Sorting a Collection Example

7. Create a driver class that will add students and then display them to screen.

```
    static void addStudents(ArrayList<Student> studentNames) {
       //Add the following student objects
       studentNames.add(new Student("Mark", "Mywords", 95));
       studentNames.add(new Student("Andrew", "Apic", 45));
       studentNames.add(new Student("Beth", "Tween", 78));
     }//end method addStudents

}//end class StudentDriver
```

8. Run and test your code to check that it works.

```
Student Details: Mark Mywords 95
Student Details: Andrew Apic 45
Student Details: Beth Tween 78
Student Details: Andrew Apic 45
Student Details: Mark Mywords 95
Student Details: Beth Tween 78
```

Comparable Interface

- The compareTo method implementation could have used any or multiple fields from our class.
- In this example the String field lastName was used to sort the students based on their last name.

```
@Override
public int compareTo(Student stud2) {
    if(lastName.compareTo(stud2.getLastName()) < 0 )
       return -1;
    if(lastName.compareTo(stud2.getLastName()) == 0 )
       return 0;
    return 1;
}//end method compareTo
```

Sorting a Collection Example

9. Update the code to sort the students by their mark.

```
@Override
public int compareTo(Student stud2) {
   if(mark.compareTo(stud2.getMark()) < 0 )
      return -1;
   if(mark.compareTo(stud2.getMark()) == 0 )
      return 0;
   return 1;
}//end method compareTo
```

When you try to base the compareTo on a primitive data type (mark is an int) you get the following error message:

```
Cannot invoke compareTo(int) on the primitive type int
```

Sorting a Collection Example

9. To compare based on a primitive data type the valueOf method must be invoked. This returns an Integer instance based on the value of the primitive.

   Update the code to use this method:

```
@Override
public int compareTo(Student stud2) {
   if((Integer.valueOf(mark).compareTo(Integer.valueOf(stud2.getMark()))
       < 0 ))
      return -1;
   if((Integer.valueOf(mark).compareTo(Integer.valueOf(stud2.getMark()))
       == 0 ))
      return 0;
   return 1;
}//end method compareTo
```

Student Output

- Driver class method calls.

```
    addStudents(studentNames);
    displayStudents(studentNames);
    Collections.sort(studentNames);
    displayStudents(studentNames);
}//end method main
```

- Output

```
Student Details: Mark Mywords 95
Student Details: Andrew Apic 45
Student Details: Beth Tween 78
Student Details: Andrew Apic 45
Student Details: Mark Mywords 95
Student Details: Beth Tween 78
```

Terminology

Key terms used in this lesson included:

- Comparable
- Deque
- HashMap
- LinkedList
- Node
- Queue
- Stack

Summary

In this lesson, you should have learned how to:

- Implement a HashMap
- Implement a stack by using a deque
- Implement Comparable Interface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