Ex. No. 8	**MULTITHREADING**
Date of Exercise	05-10-2023

1) Aim :

To write a java program which takes input as huge array of numbers in which array is split into n sub-arrays and n threads apply a bubble sort on each of the n sub-arrays.

Procedure :

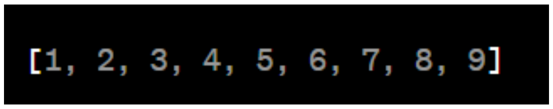
1. Start the program.
2. Create the requested classes.
3. Split the n sub arrays and n threads.
4. Apply bubble sort on each of n sub array.
5. Create another sort on each of n sub array.
6. Give the input and get the output.
7. Stop the program.

Program :

```
import java.util.concurrent.*;
import java.util.Arrays;

public class ParallelBubbleSort {
   public static void main(String[] args) throws InterruptedException, ExecutionException {
      int[] inputArray = {9, 2, 5, 1, 7, 8, 3, 4, 6};
      int n = 3;
      int subArraySize = inputArray.length / n;
      ExecutorService executor = Executors.newFixedThreadPool(n);
```

```
    Future<int[]>[] futures = new Future[n];
    for (int i = 0; i < n; i++) {
        int startIndex = i * subArraySize;
        int endIndex = (i == n - 1) ? inputArray.length : (i + 1) * subArraySize;
        int[] subArray = Arrays.copyOfRange(inputArray, startIndex, endIndex);
        Callable<int[]> task = new BubbleSortTask(subArray);
        futures[i] = executor.submit(task);
    }

    for (Future<int[]> future : futures) {
        future.get();
    }
   int[] sortedArray = mergeSortedArrays(futures);
    System.out.println(Arrays.toString(sortedArray));
    executor.shutdown();
}
   static class BubbleSortTask implements Callable<int[]> {
   private int[] subArray;
   public BubbleSortTask(int[] subArray) {
   this.subArray = subArray;
    }
    @Override
        public int[] call() {
        bubbleSort(subArray);
        return subArray;
    }
}
static void bubbleSort(int[] arr) {
    int n = arr.length;
    boolean swapped;
    for (int i = 0; i < n - 1; i++) {
        swapped = false;
        for (int j = 0; j < n - i - 1; j++) {
            if (arr[j] > arr[j + 1]) {
                int temp = arr[j];
                arr[j] = arr[j + 1];
                arr[j + 1] = temp;
                swapped = true;
            }
        }
        if (!swapped) {
            break;
        }
    }
}

    static int[] mergeSortedArrays(Future<int[]>[] futures) throws InterruptedException,
ExecutionException {
    int n = futures.length;
    int[][] sortedArrays = new int[n][];

    for (int i = 0; i < n; i++) {
        sortedArrays[i] = futures[i].get();
    }

    return mergeArrays(sortedArrays);
}

static int[] mergeArrays(int[][] arrays) {
    int totalLength = 0;
    for (int[] array : arrays) {
        totalLength += array.length;
    }

    int[] result = new int[totalLength];
    int[] indices = new int[arrays.length];

    for (int i = 0; i < totalLength; i++) {
        int minIndex = -1;
        int minValue = Integer.MAX_VALUE;

        for (int j = 0; j < arrays.length; j++) {
            if (indices[j] < arrays[j].length && arrays[j][indices[j]] < minValue) {
                minValue = arrays[j][indices[j]];
                minIndex = j;
            }
        }

        result[i] = minValue;
        indices[minIndex]++;
    }

    return result;
}
}
```

Output Screenshot :



```
[1, 2, 3, 4, 5, 6, 7, 8, 9]
```

Result :

The above program has been successfully executed and verified.

2) Aim :

To write a java program to check with the Airport to see if it has an available runway before it's able to take off or land using multi-threading.

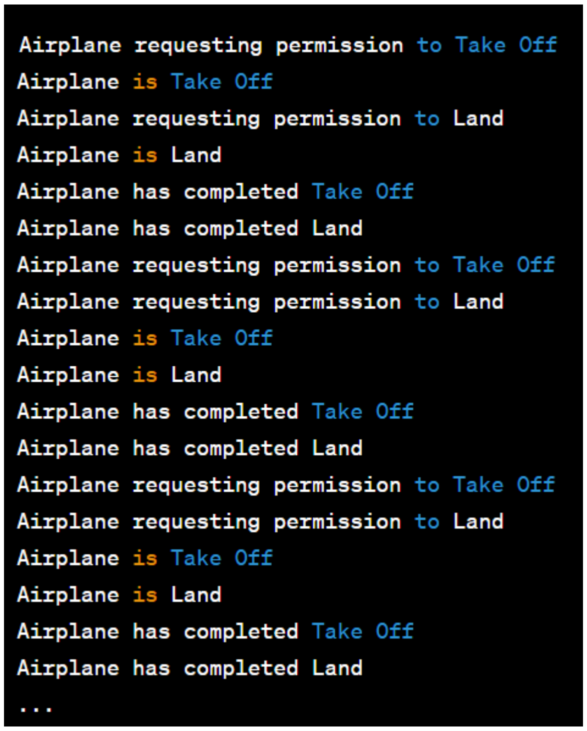
Procedure :

1. Start the program.
2. Create all the required classes.
3. Implement a mechanism for airplanes to request access to the runway from the airport
4. The airport should grant access if there are available runways; otherwise, airplanes should wait.
5. After completing their operation (take off or landing), airplanes should release the runway.
6. Stop the programe

Program :

```
import java.util.concurrent.Semaphore;

public class AirportSimulation {
 private static final int NUM_RUNWAYS = 3;
  private static Semaphore runwaySemaphore = new Semaphore(NUM_RUNWAYS);

    public static void main(String[] args) {
        Thread takeOffThread = new Thread(new Airplane("Take Off"));
        Thread landThread = new Thread(new Airplane("Land"));

        takeOffThread.start();
        landThread.start();
    }
    static class Airplane implements Runnable {
        private String operation;

        public Airplane(String operation) {
            this.operation = operation;
        }

        @Override
        public void run() {
            while (true) {
                try {
                    System.out.println("Airplane requesting permission to " + operation);
                    runwaySemaphore.acquire(); // Request permission to use a runway

                    System.out.println("Airplane is " + operation);
                    Thread.sleep(2000); // Simulate the operation

                    System.out.println("Airplane has completed " + operation);
                    runwaySemaphore.release(); // Release the runway
                } catch (InterruptedException e) {
                    e.printStackTrace();
                }
            }
        }
    }
}
```

Output Screenshot :



```
Airplane requesting permission to Take Off
Airplane is Take Off
Airplane requesting permission to Land
Airplane is Land
Airplane has completed Take Off
Airplane has completed Land
Airplane requesting permission to Take Off
Airplane requesting permission to Land
Airplane is Take Off
Airplane is Land
Airplane has completed Take Off
Airplane has completed Land
Airplane requesting permission to Take Off
Airplane requesting permission to Land
Airplane is Take Off
Airplane is Land
Airplane has completed Take Off
Airplane has completed Land
...
```

Result :

The above program has been successfully executed and verified.