Lab Session 1-Report

Concurrency and Parallelism

- Submitted by
Cyril Naves Samuel

Exercise 1: The *Thread* class

The goal of this very first exercise is to get used to the usage of the *Thread* class in Java (*java.lang*).
1/ Write a program where two threads print concurrently on the standard output (*System.out*) a different message 10000 times each.
2/ After launching the threads, the main will also print 10000 times a message.

Summary for the Thread Class implementation:

1) Main Class is extending Thread Class from the java.lang package.
2) Thread Class implements Runnable Interface and extends Object Class
3) Here two New Threads are created and then started to print different messages for 10000 times
4) Also the main method has a provided logic to print the text 10000 times

Code:

```
package masterInt.CandP.exo1;


public class Exo1 extends Thread {


String message;



	/**
	 * Constructor
	 *
	 * @param _message
	 *            The message to print
	 */
	public Exo1(String inpmessage) {
		message = inpmessage;
	}

	@Override
	public void run() {
		// Print the message 10000 times
		for (int i = 0; i < 10000; i++) {
			System.out.println(message + "no:" + (i + 1));
		}
	}

	/**
	 * Main method to print concurrent messages through two different threads
	 * @param args
	 */
	public static void main(String[] args) {
		Exo1 exo1 = new Exo1("Thread1Printing");
		exo1.start();
		Exo1 exo2 = new Exo1("Thread2Printing");
		exo2.start();
		for (int i = 0; i < 10000; i++) {
			System.out.println("main" + "no:" + (i + 1));
```

```
            }

      }

}
```

Sample Output: Since all the 30000 printout are not captured due to space constraint

```
Thread2Printingno:9976
Thread2Printingno:9977
Thread2Printingno:9978
Thread1Printingno:9979
Thread1Printingno:9980
Thread2Printingno:9981
```

Exercise 2: The *Runnable* interface

Write a program that prints a frame (*javax.swing.JFrame*) containing two text fields (*javax.swing.JTextField*) and two buttons (*javax.swing.JButton*). Each button is a runnable entity that is started when one clicks on it (*java.awt.event.ActionListener* and addActionListener()).

When started, it prints the content of the associated text field on the standard output every 500 ms (*Thread.sleep()*). If the text in the field changes, the printed message changes accordingly. Of course, both buttons can be activated simultaneously.

When clicking one more time on the button, it stops printing, then resumes, and so on. When the frame is closed, the two runnable entities are killed!

Summary for the Runnable Interface implementation:

1) Here Runnable Button Class extends JButton Class as well as implements Runnable Interface to get the properties of swing as well as Concurrent Execution of Threads
2) Run method is overridden to print the value in the Jtext field value passed through constructor
3) Exo2 has the button, Text field in the current window frame and awaits the action listener
4) When the button is clicked the button threads are then started .
5) Conditional checks are implemented in the action listener to handle the stop as well as resume the thread printing operation
6) Finally in window closing method the two threads are then killed.

Code:

```
package masterInt.CandP.exo2;

import javax.swing.JButton;
import javax.swing.JTextField;

public class RunnableButton extends JButton implements Runnable {

	// Please ignore that
	private static final long serialVersionUID = 7453535863156182464L;

	JTextField textfield;

	public RunnableButton(String text, JTextField _tf) {
		super(text);
		this.textfield = _tf;
	}

	@Override
	public void run() {
		// Print the content of the text field on the output stream
		while (true) {
			System.out.println(textfield.getText());
			try {
				Thread.sleep(500);
			} catch (InterruptedException e) {
				// TODO Auto-generated catch block
				e.printStackTrace();
			}
		}
	}

}
```

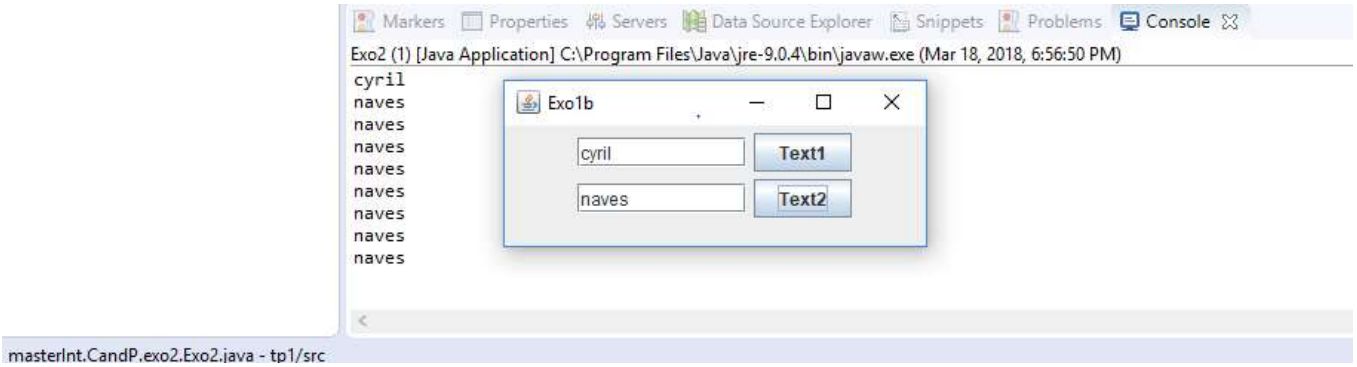
```
package masterInt.CandP.exo2;

import java.awt.FlowLayout;
import java.awt.event.ActionEvent;
import java.awt.event.ActionListener;
import java.awt.event.WindowEvent;
import java.awt.event.WindowListener;

import javax.swing.JFrame;
import javax.swing.JTextField;

public class Exo2 extends JFrame implements ActionListener, WindowListener {

	private static final long serialVersionUID = -2818867002346363736L;

	private RunnableButton button1, button2;
```

```
private Thread thread1, thread2;

private String textButton1, textButton2;

public Exo2(String title) {
	// Set up the frame
	super(title);
	this.setDefaultCloseOperation(DO_NOTHING_ON_CLOSE);
	this.addWindowListener(this);
	textButton1 = "button1";
	textButton2 = "button2";
	this.setSize(300, 120);
	this.setLayout(new FlowLayout());
	JTextField tf1 = new JTextField("Text1", 10);
	JTextField tf2 = new JTextField("Text2", 10);

	// Set up button1
	button1 = new RunnableButton("Text1", tf1);
	button1.addActionListener(this);

	// Set up button 2
	button2 = new RunnableButton("Text2", tf2);
	button2.addActionListener(this);
	// Add button 1 and 2 to the frame
	this.add(tf1);
	this.add(button1);
	this.add(tf2);
	this.add(button2);

}

// This method is called when any of the button is clicked
@SuppressWarnings("deprecation")
// At the first click, the corresponding thread is started
// At the subsequent, the state of the thread is changed
// from active to inactive or vice versa
@Override
public void actionPerformed(ActionEvent e) {
	if (e.getSource() instanceof RunnableButton) {
		RunnableButton button = (RunnableButton) e.getSource();

		// Identify the button
		if (thread1 == null && button.getText() == "Text1") {
			thread1 = new Thread(button1);
			thread1.start();
			try {
				Thread.sleep(500);
			} catch (InterruptedException e1) {
				// TODO Auto-generated catch block
				e1.printStackTrace();
			}
		} else if (thread2 == null && button.getText() == "Text2") {
			thread2 = new Thread(button2);
			thread2.start();
			try {
				thread2.sleep(500);
			} catch (InterruptedException e1) {
				// TODO Auto-generated catch block
```

```
                                e1.printStackTrace();
                        }

                } else if (thread1 != null &&
thread1.getState().toString().equalsIgnoreCase("TIMED_WAITING")
                                && thread1.getName().equalsIgnoreCase("suspend") &&
button.getText().equalsIgnoreCase("Text1")) {
                        thread1.resume();
                        thread1.setName("");
                } else if (thread2 != null &&
thread2.getState().toString().equalsIgnoreCase("TIMED_WAITING")
                                && thread2.getName().equalsIgnoreCase("suspend") &&
button.getText().equalsIgnoreCase("Text2")) {
                        thread2.resume();
                        thread2.setName("");
                } else if (thread1 != null &&
thread1.getState().toString().equalsIgnoreCase("TIMED_WAITING")
                                && button.getText().equalsIgnoreCase("Text1")) {
                        thread1.suspend();
                        thread1.setName("suspend");
                } else if (thread2 != null &&
thread2.getState().toString().equalsIgnoreCase("TIMED_WAITING")
                                && button.getText().equalsIgnoreCase("Text2")) {
                        thread2.suspend();
                        thread2.setName("suspend");
                }

        }

    }

    public static void main(String[] arg) {
        Exo2 main = new Exo2("Exo1b");
        main.setVisible(true);
    }

    // Kill the thread before closing the windows
    @Override
    public void windowClosing(WindowEvent e) {
        if (thread1 != null) {
            thread1.stop();
        }
        if (thread2 != null) {
            thread2.stop();
        }
        this.setVisible(false);
        System.exit(0);

    }

    @Override
    public void windowActivated(WindowEvent e) {
    }

    @Override
    public void windowClosed(WindowEvent e) {
    }

    @Override
```

```
	public void windowDeactivated(WindowEvent e) {
	}

	@Override
	public void windowDeiconified(WindowEvent e) {
	}

	@Override
	public void windowIconified(WindowEvent e) {
	}

	@Override
	public void windowOpened(WindowEvent e) {
	}

}
```

Output:



Exercise 3: PipedStream

Write a program where a reader thread catches the stream of characters typed on the keyboard (*System.in*). When a full line has been typed (the key <enter> has been pressed) (*java.util.Scanner*), the line is put into a pipe (*java.io.PipedOutputStream*).

At the other end of the pipe, another thread reads the content of the pipe (*PipedInputStream*) and prints it in the text area (*javax.swing.JTextArea*) of a frame, line by line.

Could you kill the reader when the frame is closed?

Summary for the PipedStream implementation:

1) Reader Class handles the input of the text from the console which gets the input from the console through Scanner Class
2) In Reader PipedOutPutStream is used to send the message through the Pipe which is passed thorugh the constructor instantiation from the main Exo3 Class
3) In Writer PipedInputStream is used to receive the message from the pipe in bytes form (int) then converted to char which is then appended to string.
4) Exo3 Class contains the instantiation of PipedInputStream , PipedOutPutStream, as well as the instance variable are passed to the object constructors of Writer and Reader Class.
5) PipedInputStream is connected to the PipedOutPutStream through the connect method.
6) Then ExecutorService is used to create a threadpool with the threads of Reader and Writer objects
7) Threads are started through Executor Service.
8) Window Closing Event is handled in the where the current thread running is closed.

Code:

```
package masterInt.CandP.exo3;

import java.awt.FlowLayout;
import java.awt.event.WindowEvent;
import java.awt.event.WindowListener;
import java.io.BufferedReader;
import java.io.ByteArrayInputStream;
import java.io.DataInputStream;
import java.io.IOException;
import java.io.InputStream;
import java.io.InputStreamReader;
import java.io.PipedInputStream;

import javax.swing.JFrame;
import javax.swing.JTextArea;

public class Printer extends JFrame implements WindowListener, Runnable {

private static final long serialVersionUID = 4835711038057686272L;
```

```
PipedInputStream pipedInputStream = null;

private JTextArea textarea;

public Printer(PipedInputStream _pipe) {

	this.pipedInputStream = _pipe;

	// Set up the window
	this.setSize(250, 200);
	this.setDefaultCloseOperation(DO_NOTHING_ON_CLOSE);
	this.setLayout(new FlowLayout());
	this.addWindowListener(this);

	// Set up the text area
	textarea = new JTextArea(9, 20);
	textarea.setEditable(false);
	this.add(textarea);

	this.setVisible(true);
}

// Read when available
// And print in the Text area
@Override
public void run() {
	while (true) {
		StringBuilder fina = new StringBuilder();
		char text;
		int c;
		try {
			int count = pipedInputStream.available();
			for (int i = 0; i < count; i++) {
				text = (char) pipedInputStream.read();
				fina.append(text);
			}
			if (!fina.toString().isEmpty()) {
				textarea.append(fina.toString() + "\n");
			}
		} catch (IOException e) {
			// TODO Auto-generated catch block
			e.printStackTrace();
		}
		try {
			Thread.sleep(5000);
		} catch (InterruptedException e) {
			// TODO Auto-generated catch block
			e.printStackTrace();
		}
	}
}

public String convertto(InputStream is) {
	StringBuilder sb = null;
	String a;
	BufferedReader br = new BufferedReader(new InputStreamReader(is));
	try {
		while ((a = br.readLine()) != null) {
			sb.append(a);
```

```
                }
        } catch (IOException e) {
                // TODO Auto-generated catch block
                e.printStackTrace();
        }
        return sb.toString();
}

// Kill the thread before killing the program
@Override
public void windowClosing(WindowEvent arg0) {
        Thread.currentThread().interrupt();
        this.setVisible(false);
        System.exit(0);
}

@Override
public void windowActivated(WindowEvent arg0) {
}

@Override
public void windowClosed(WindowEvent arg0) {
}

@Override
public void windowDeactivated(WindowEvent arg0) {
}

@Override
public void windowDeiconified(WindowEvent arg0) {
}

@Override
public void windowIconified(WindowEvent arg0) {
}

@Override
public void windowOpened(WindowEvent arg0) {
}

}
```

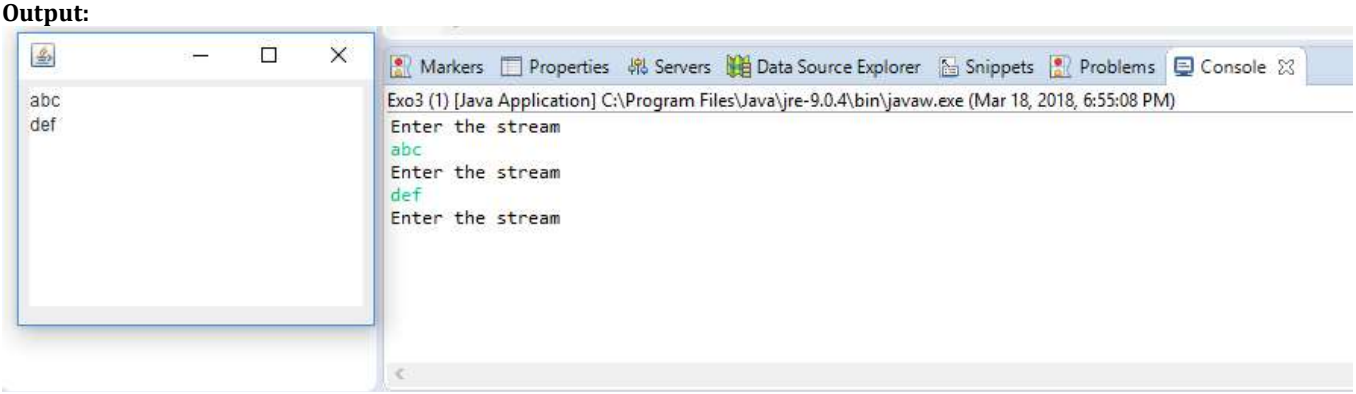
```java
package masterInt.CandP.exo3;

import java.io.IOException;
import java.io.PipedOutputStream;
import java.util.Scanner;

public class Reader implements Runnable {
	String lines = null;
	PipedOutputStream pipedOutputStream = null;

	public Reader(PipedOutputStream pipedOutputStream) {
		this.pipedOutputStream = pipedOutputStream;
	}

	// Read input stream when available
```

```
	// send it in the pipe
	public void run() {
		while (true) {
			System.out.println("Enter the stream");
			Scanner scanner = new Scanner(System.in);
			String total = "";
			String input = scanner.next();
			total += input;
			if (true) {

				try {
					pipedOutputStream.write(total.getBytes());
					try {
						Thread.sleep(500);
					} catch (InterruptedException e) {
						// TODO Auto-generated catch block
						e.printStackTrace();
					}
				} catch (IOException e) {
					// TODO Auto-generated catch block
					e.printStackTrace();
				}
			}
		}
	}
}
```

```
package masterInt.CandP.exo3;

import java.io.IOException;
import java.io.PipedOutputStream;
import java.util.Scanner;
import java.util.concurrent.ExecutorService;
import java.util.concurrent.Executors;
import java.io.PipedInputStream;

public class Exo3 {
public static void main(String[] args) {

	PipedOutputStream pipedOutputStream = new PipedOutputStream();
	PipedInputStream pipedInputStream = new PipedInputStream();
	try {
		pipedOutputStream.connect(pipedInputStream);
	} catch (IOException e) {
		// TODO Auto-generated catch block
		e.printStackTrace();
	}

	// Create the printer and the reader
	Reader reader = new Reader(pipedOutputStream);
	Printer printer = new Printer(pipedInputStream);
	// Start them
	Thread threadReader = new Thread(reader);
	Thread threadWriter = new Thread(printer);

	ExecutorService service = Executors.newFixedThreadPool(2);
```

```
        service.execute(threadReader);
        service.execute(threadWriter);
}
}
```

Output:



Exercise 4: Parallel bubble sort

Write a program which takes as input a huge array of numbers. This array is split into *n* sub-arrays and *n* threads apply a bubble sort on each of the *n* sub-arrays. Lastly, another thread merges the *n* sorted sub-arrays into one with the same size as the original array. Of course, the resulting array should be sorted.
Compare the execution of a sequential bubble sort on an array of 40000 elements with the execution of the parallel version (as described above).

Summary for the Parallel Bubble Sort implementation:

1) Bubble Sorter Class Implements the Runnable Interface and overrides the run() method where the bubble_srt() method is called.
2) In Exo4 the Divide and Conquer method is applied to divide the 40000 elements to each of 10000 elements 4 times(n times)
3) Here 4 threads are run in concurrent mode and all of them are made to join (wait for the other threads to finish execution)
4) Then each of the individual rows are then merged using fusion of the input array.
5) Here fusion thread is made to execute and then made to join so that when the execution is complete the result array is then
6) Parallel Execution of threads employs dividing the computation task upto n threads and then they are finally merged using a single thread.

7) On comparing the parallel execution of the bubble sort , with the sequential bubble sort
Sequential bubble sort time: 4087 ms
Parallel Sorting Time: 236 ms
Parallel Sorting Time is much faster compared to the sequential sorting since the time to compute a much bigger elements of 10000 elements of 4 times is much easier compared to 40000 since he time to merge or fuse a sorted sub array of elements is much faster.

Code:

```
package masterInt.CandP.exo4;

//This class implements the bubble sorting algorithm in a thread
public class BubbleSorter implements Runnable {
	private int[] tab;


	public BubbleSorter(int[] _tab) {
		super();
		this.tab = _tab;
		// ...
	}


	// Run the bubble sort algorithm on tab.
	@Override
	public void run() {
		long start_time = System.currentTimeMillis();
		bubble_srt();
		System.out.println("Bubble Sorting time=" + (System.currentTimeMillis()-start_time)
+ " ms");
	}

	// Here is the bubble sort algorithm on tab
	public void bubble_srt() {
		int t, n = tab.length;
		for (int i = 0; i < n; i++)
			for (int j = 1; j < (n - i); j++)
				if (tab[j - 1] > tab[j]) {
					t = tab[j - 1];
					tab[j - 1] = tab[j];
					tab[j] = t;
				}
	}

	// This main aims at trying the bubble sorting algorithm and compare the
	// sequential sorting with the parallel sorting

	public static void main(String[] args) {
		// Set up the table with random values
		int size = 40000;
		int[] tab = new int[size];
		for (int i = 0; i < size; i++) {
			tab[i] = (int) (Math.random() * size);
		}
		// Do the bubble sort ...
		long start_time = System.currentTimeMillis();
```

```
		int t, n = tab.length;
		for (int i = 0; i < n; i++) {
			for (int j = 1; j < (n - i); j++) {
				if (tab[j - 1] > tab[j]) {
					t = tab[j - 1];
					tab[j - 1] = tab[j];
					tab[j] = t;
				}
			}
		}
		System.out.println("Bubble Sorting time=" + (System.currentTimeMillis() -
start_time) + " ms");
	}

}
```

```
package masterInt.CandP.exo4;

//This class implements the fusion operation in a thread
public class Fusion implements Runnable {
	private int[][] tab;
	private int[] result;

	public Fusion(int[][] _tab) {
		this.tab = _tab;

	}

	// Run the fusion algorithm on tab
	public void run() {
		long start_time = System.currentTimeMillis();
		fusion();
		System.out.println("Fusion time=" + (System.currentTimeMillis() - start_time) + "
ms");
	}

	// Implement the fusion algorithm
	private int[] fusion() {
		int size = 0;
		int tabIndex;

		// Set up the size of the resulting merged table
		for (int i = 0; i < tab.length; i++)
			size += tab[i].length;

		int[] result = new int[size];

		// Set up the indices table
		int[] indices = new int[tab.length];

		for (int i = 0; i < tab.length; i++)
			indices[i] = 0;

		// Fill up the resulting merged table
		for (int i = 0; i < result.length; i++) {
			// Find the first table where there is still values to merge
			tabIndex = -1;
			for (int j = 0; j < tab.length; j++)
```

```
                        if (indices[j] < tab[j].length) {
                                tabIndex = j;
                                break;
                        }

                    // Compare the value in the current table with the value in the next table
                    for (int j = tabIndex + 1; j < tab.length; j++) {
                        if ((indices[j] < tab[j].length) && (tab[tabIndex][indices[tabIndex]] >
tab[j][indices[j]]))
                                tabIndex = j;
                    }

                    // Add the correct value to the resulting merged table
                    result[i] = tab[tabIndex][indices[tabIndex]];

                    // Increase the index for the correct table
                    indices[tabIndex]++;
                }
                this.result = result;
                return result;
        }

        // Get the resulting merged table
        public int[] getResult() {
                return result;
        }

}
```

```
package masterInt.CandP.exo4;

public class Exo4 {

        /**
         * @param args
         */
        public static void main(String[] args) {
                // Set up the table with random values
                int nb = 4; // number of tables
                int size = 10000;// Size of each table
                int[][] tab = new int[nb][size];
                for (int i = 0; i < nb; i++) {
                        for (int j = 0; j < size; j++) {
                                tab[i][j] = (int) (Math.random() * size);
                        }
                }
                /*
                 * //Print the original tabs for(int i=0;i<nb;i++) { for(int j=0;j<size;j++)
                 * System.out.print(""+tab[i][j]); System.out.println("\n"); }
                 */

                // Create the bubble sorters
                BubbleSorter bubbleSorterfirst = new BubbleSorter(tab[0]);
                Thread firstthread = new Thread(bubbleSorterfirst);
                BubbleSorter bubbleSortersecond = new BubbleSorter(tab[1]);
                Thread secondthread = new Thread(bubbleSortersecond);
                BubbleSorter bubbleSorterThird = new BubbleSorter(tab[2]);
                Thread thirdthread = new Thread(bubbleSorterThird);
```

```
		BubbleSorter bubbleSorterfourth = new BubbleSorter(tab[3]);
		Thread fourththread = new Thread(bubbleSorterfourth);
		// Get the current time
		long start_time = System.currentTimeMillis();
		// Do bubble sorting
		firstthread.start();
		secondthread.start();
		thirdthread.start();
		fourththread.start();
		// Waiting for the Bubble sorters
		try {
			firstthread.join();
			secondthread.join();
			thirdthread.join();
			fourththread.join();
		} catch (InterruptedException e) {
			// TODO Auto-generated catch block
			e.printStackTrace();
		}

		// Do the fusion
		// Wait for the fusion to complete

		Fusion fusion = new Fusion(tab);
		Thread threadfusion = new Thread(fusion);
		threadfusion.start();
		try {
			threadfusion.join();
		} catch (InterruptedException e) {
			// TODO Auto-generated catch block
			e.printStackTrace();
		}

		int[] mergedTab = fusion.getResult();
		// Print the total execution time
		System.out.println("Total time=" + (System.currentTimeMillis() - start_time) +
"ms");
		// Print result
		for (int ij = 0; ij < mergedTab.length; ij++) {
			System.out.println("" + mergedTab[ij]);
		}

	}

}
```

Output:

Parallel Sorting:
Bubble Sorting time=227 ms
Bubble Sorting time=227 ms
Bubble Sorting time=228 ms
Bubble Sorting time=230 ms
Fusion time=5 ms
Total time=236ms

Sequential Sorting:
Bubble Sorting time=4087 ms