6 Concurrency - 2

04 June 2024 21:15

Agenda :

1. Executor
2. Callable
3. Multithreaded Merge Sort
4. Intro to adder Subtractor Problem

1. Executors

- In a multithreaded environment, we divide the responsibilities into Parts
  a. **Client :** knows What task to run
  b. **Executors :** knows the best way to efficiently run the task, in order to achieve concurrency.

- In large-scale applications, it makes sense to separate thread management and creation from the rest of the application. Objects that encapsulate these functions are known as *executors*.
- Way to implement executors :
  - **Executor Interface**
  - **Thread pools**
  - **Fork / join**
- The java.util.concurrent package defines three executor interfaces:
  - **Executor**, a simple interface that supports launching new tasks.
  - **ExecutorService**, a subinterface of Executor, which adds features that help manage the life cycle, both of the individual tasks and of the executor itself.
  - **ScheduledExecutorService**, a subinterface of ExecutorService, supports future and/or periodic execution of tasks.

The Executor Interface

- The Executor interface provides a single method, execute, designed to be a drop-in replacement for a common thread-creation idiom.

  (new Thread(r)).start();
  e.execute(r);

- The executor implementations in java.util.concurrent are designed to make full use of the more advanced ExecutorService and ScheduledExecutorService interfaces, although they also work with the base Executor interface.

The Executor Service Interface

- The ExecutorService interface supplements execute with a similar, but more versatile submit method.
  Like execute, submit accepts Runnable objects, but also accepts **Callable** objects, which allow the task to return a value.

- The submit method returns a Future object, which is used to retrieve the Callable return value and to manage the status of both Callable and Runnable tasks.

- Finally, ExecutorService provides a number of methods for managing the shutdown of the executor.

The ScheduledExecutorService Interface

- The ScheduledExecutorService interface supplements the methods of its parent ExecutorService with schedule, which executes a Runnable or Callable task after a specified delay.

- In addition, the interface defines **scheduleAtFixedRate** and **scheduleWithFixedDelay**, which executes specified tasks repeatedly, at defined intervals.

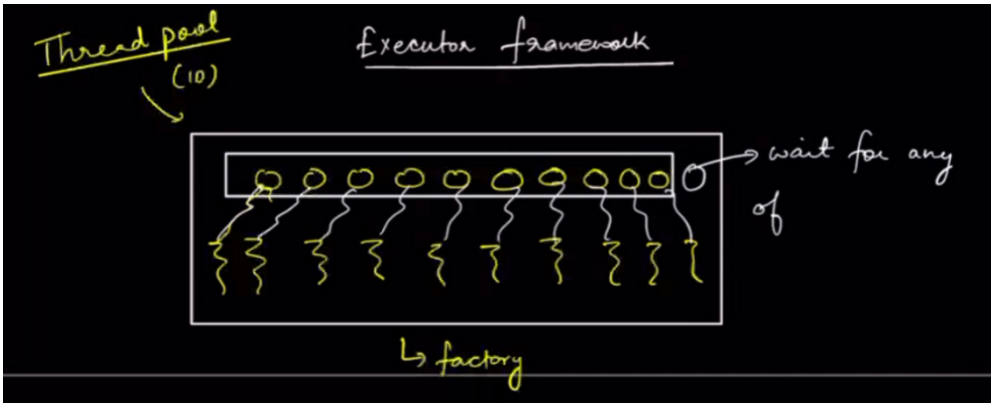
Thread Pool

- Most of the executor implementations in java.util.concurrent use *thread pools*, which consist of *worker threads*. This kind of thread exists separately from the Runnable and Callable tasks it executes and is often used to execute multiple tasks.

- One common type of thread pool is the *fixed thread pool*. This type of pool always has a specified number of threads running; if a thread is somehow terminated while it is still in use, it is automatically replaced with a new thread.

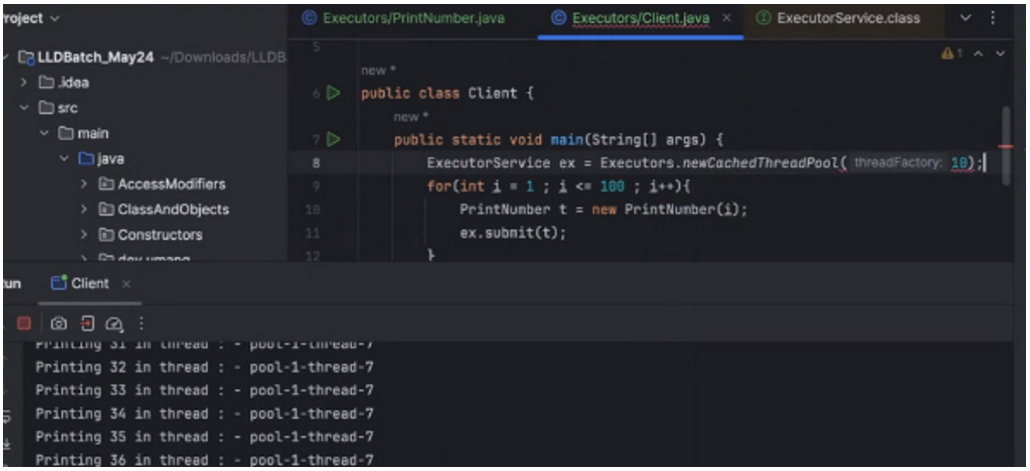
- A simple way to create an executor that uses a fixed thread pool is to invoke the **newFixedThreadPool** factory method in **java.util.concurrent.Executors** This class also provides the following factory methods:

    - The **newCachedThreadPool** method creates an executor with an expandable thread pool. This executor is suitable for applications that launch many short-lived tasks.
    - The **newSingleThreadExecutor** method creates an executor that executes a single task at a time.

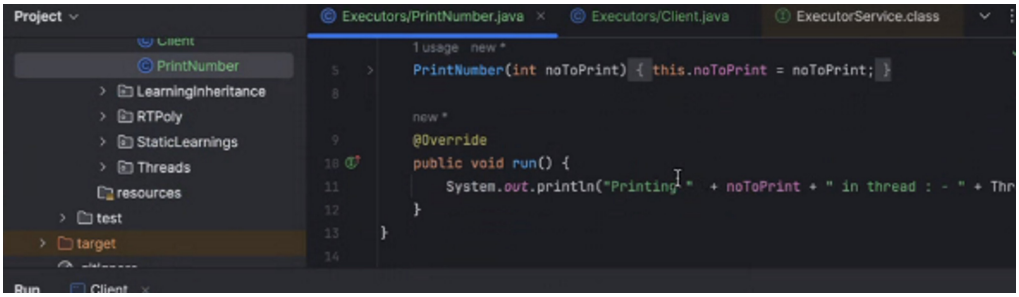


Waits for any other thread to finish to assign other task.

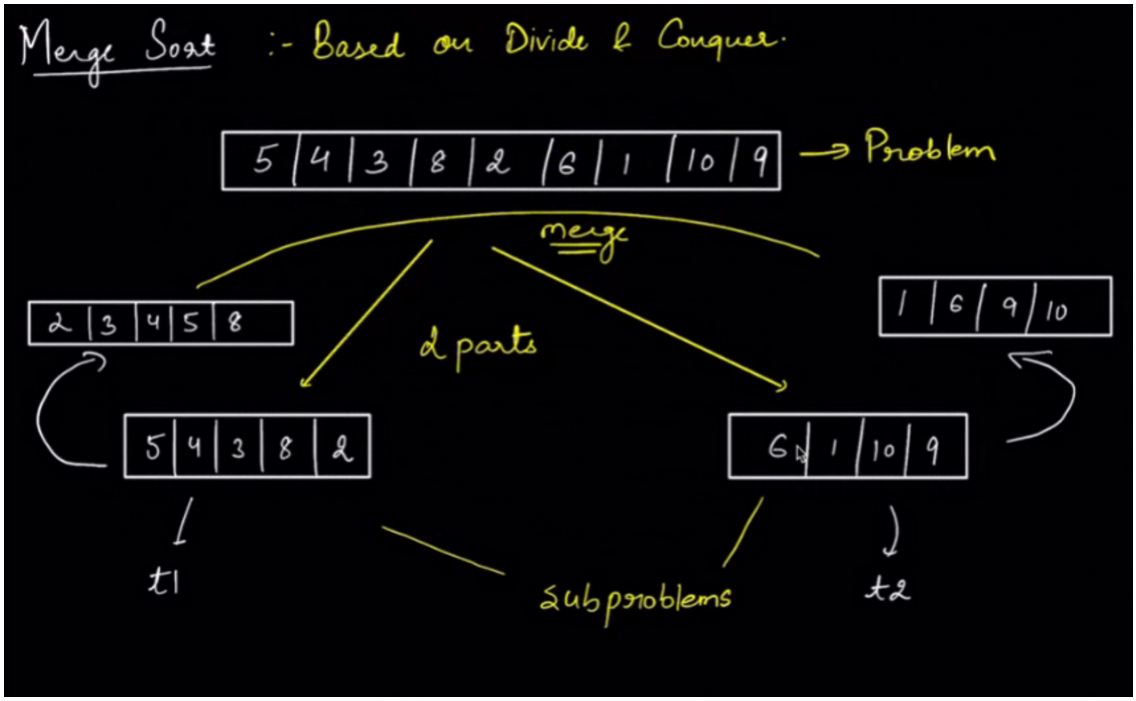
- Example of Executor Implementation



Newcatchedthread pool passed with parameter creates that many threads.



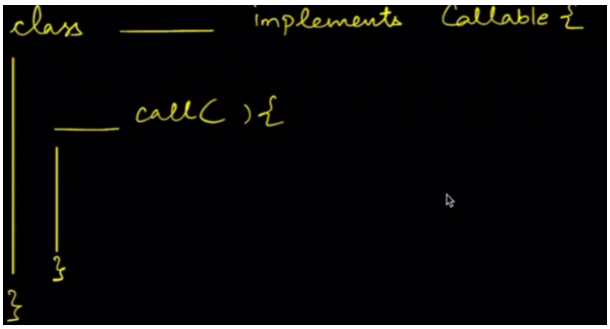
Merge Sort with Threads to perform sorting concurrently



We cannot use run(), (runnable interface) as it does not return anything.
So we need Callable interface here in this case.

2. Callable

Callable : Runnable + Returns some data.



3. Multithreaded Merge Sort

Client.java

```
package MergeSortMultiThreaded;

import java.util.List;
import java.util.concurrent.ExecutionException;
import java.util.concurrent.ExecutorService;
import java.util.concurrent.Executors;
import java.util.concurrent.Future;


public class Client {
   public static void main(String[] args) throws ExecutionException, InterruptedException {
      ExecutorService ex = Executors.newCachedThreadPool();

      List<Integer> ls = List.of(1,4,56,3,2,43,2,3,32,23,3);
```

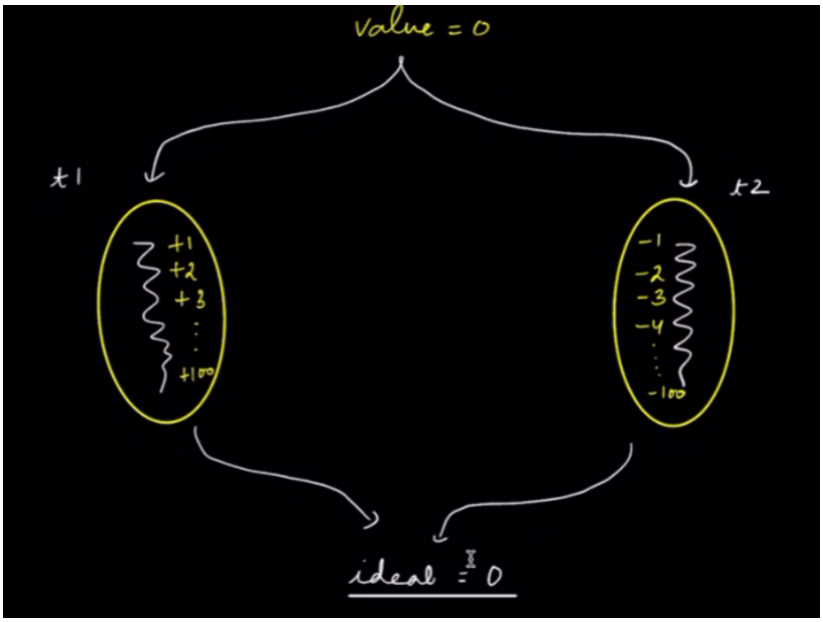
```
        Sorter t = new Sorter(ls, ex);

        Future<List<Integer>> res = ex.submit(t);

        ls = res.get();

        System.out.println(ls);

    }
}
```

Sorter.java

```
package MergeSortMultiThreaded;

import java.util.ArrayList;
import java.util.List;
import java.util.concurrent.Callable;
import java.util.concurrent.ExecutorService;
import java.util.concurrent.Future;

public class Sorter implements Callable<List<Integer>> {
    List<Integer> arrayToSort;
    ExecutorService ex;
    Sorter(List<Integer> arrayToSort, ExecutorService ex){
        this.arrayToSort = arrayToSort;
        this.ex = ex;
    }
    @Override
    public List<Integer> call() throws Exception {
        //Write the entire merge sort code
        if(arrayToSort.size() <= 1){
            return arrayToSort;
        }

        int mid = arrayToSort.size() / 2;
        /*
        First half - 0 to mid - 1
        second half - mid to size - 1
         */

        List<Integer> leftHalf = new ArrayList<>();
        for(int i = 0 ; i < mid ; i++){
            leftHalf.add(arrayToSort.get(i));
        }

        List<Integer> rightHalf = new ArrayList<>();
        for(int i = mid ; i < arrayToSort.size() ; i++){
            rightHalf.add(arrayToSort.get(i));
        }

        Sorter task1 = new Sorter(leftHalf, ex);
        Sorter task2 = new Sorter(rightHalf, ex);

        Future<List<Integer>> leftSortedArray = ex.submit(task1);
        Future<List<Integer>> rightSortedArray = ex.submit(task2);
        leftHalf = leftSortedArray.get();
        rightHalf = rightSortedArray.get();

        /*
        merge left and right half
         */

        List<Integer> finalMergedArray = new ArrayList<>();

        int i = 0 , j = 0;
```

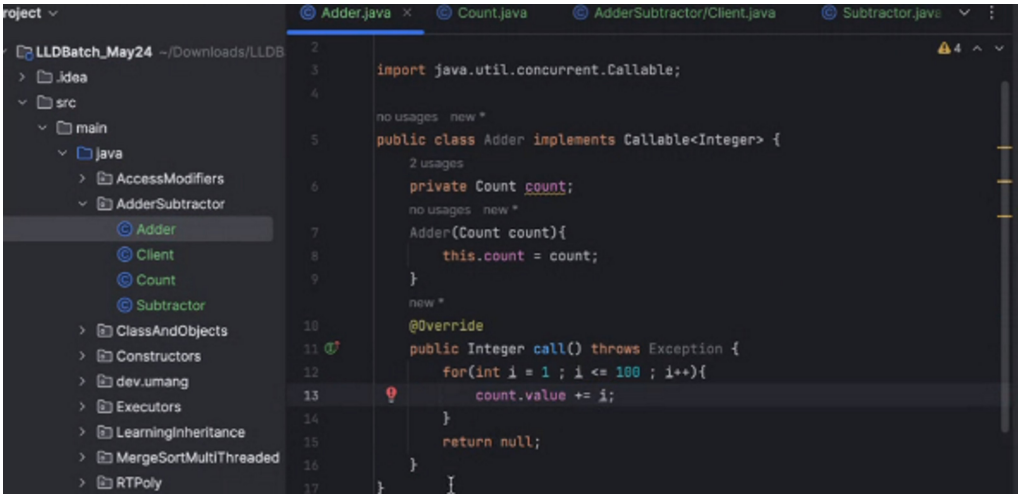
```
    while(i < leftHalf.size() && j < rightHalf.size()){
      if(leftHalf.get(i) < rightHalf.get(j)){
        finalMergedArray.add(leftHalf.get(i));
        i++;
      }else{
        finalMergedArray.add(rightHalf.get(j));
        j++;
      }
    }

    while(i < leftHalf.size()){
      finalMergedArray.add(leftHalf.get(i));
      i++;
    }

    while(j < rightHalf.size()){
      finalMergedArray.add(rightHalf.get(j));
      j++;
    }

    return finalMergedArray;
  }
}
```

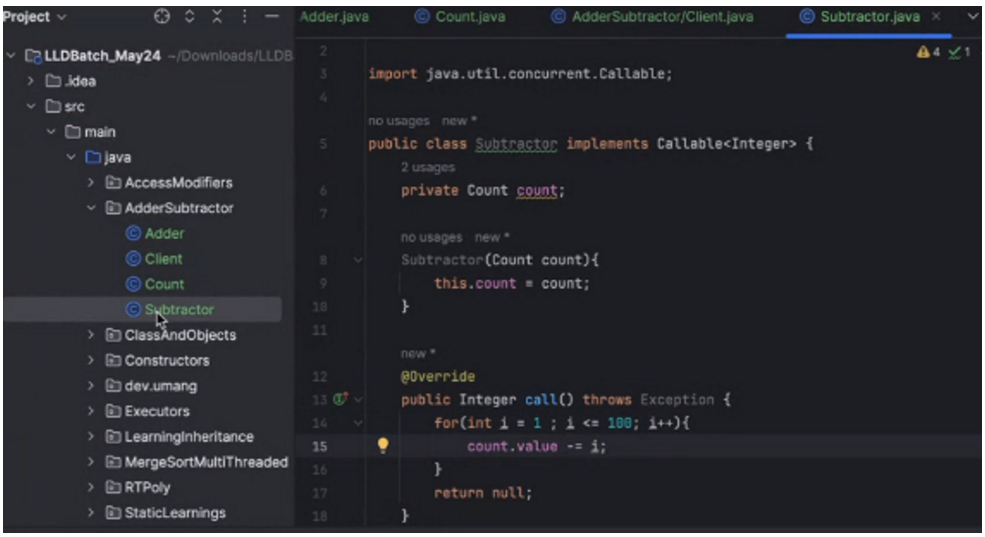
4. Synchronization Problem (Adder Subtractor Problem)



But since both the threads are not synchronized result need not to be 0.

Code :

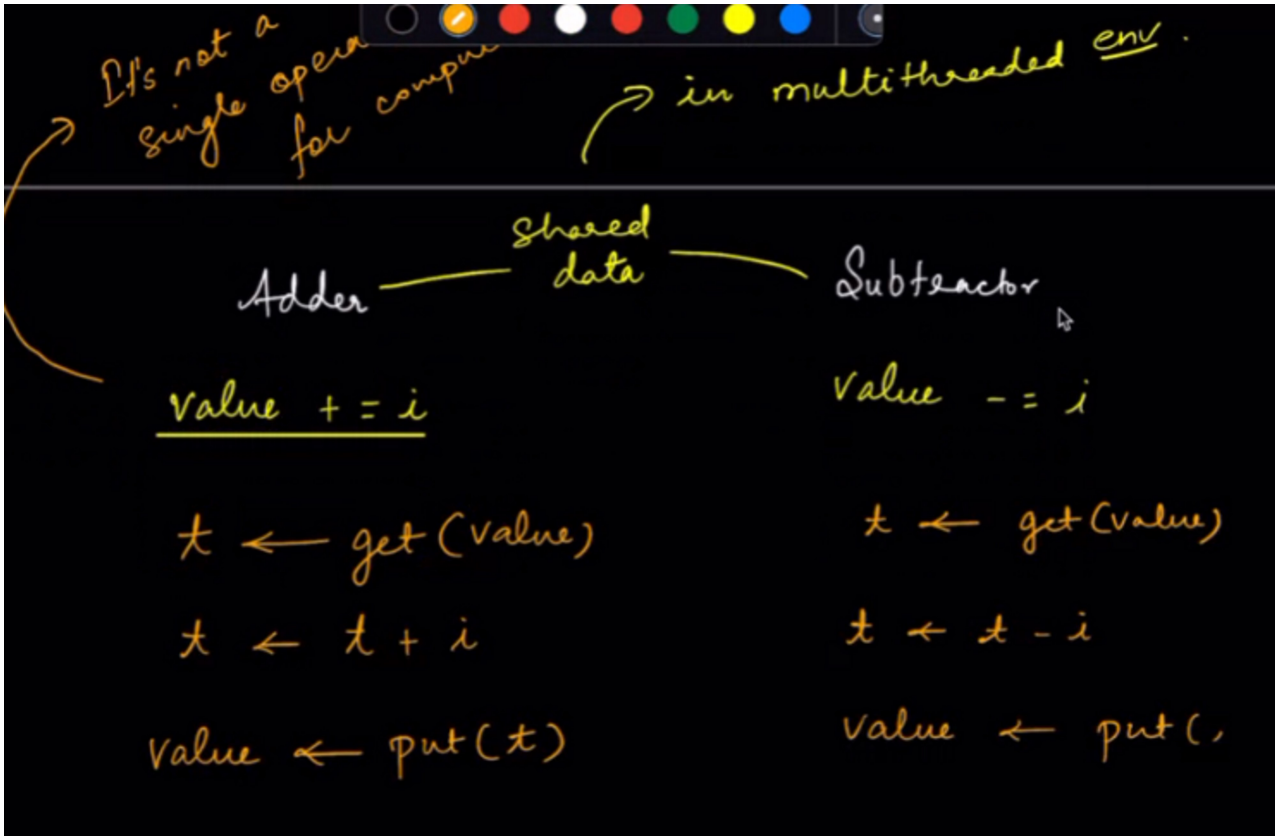


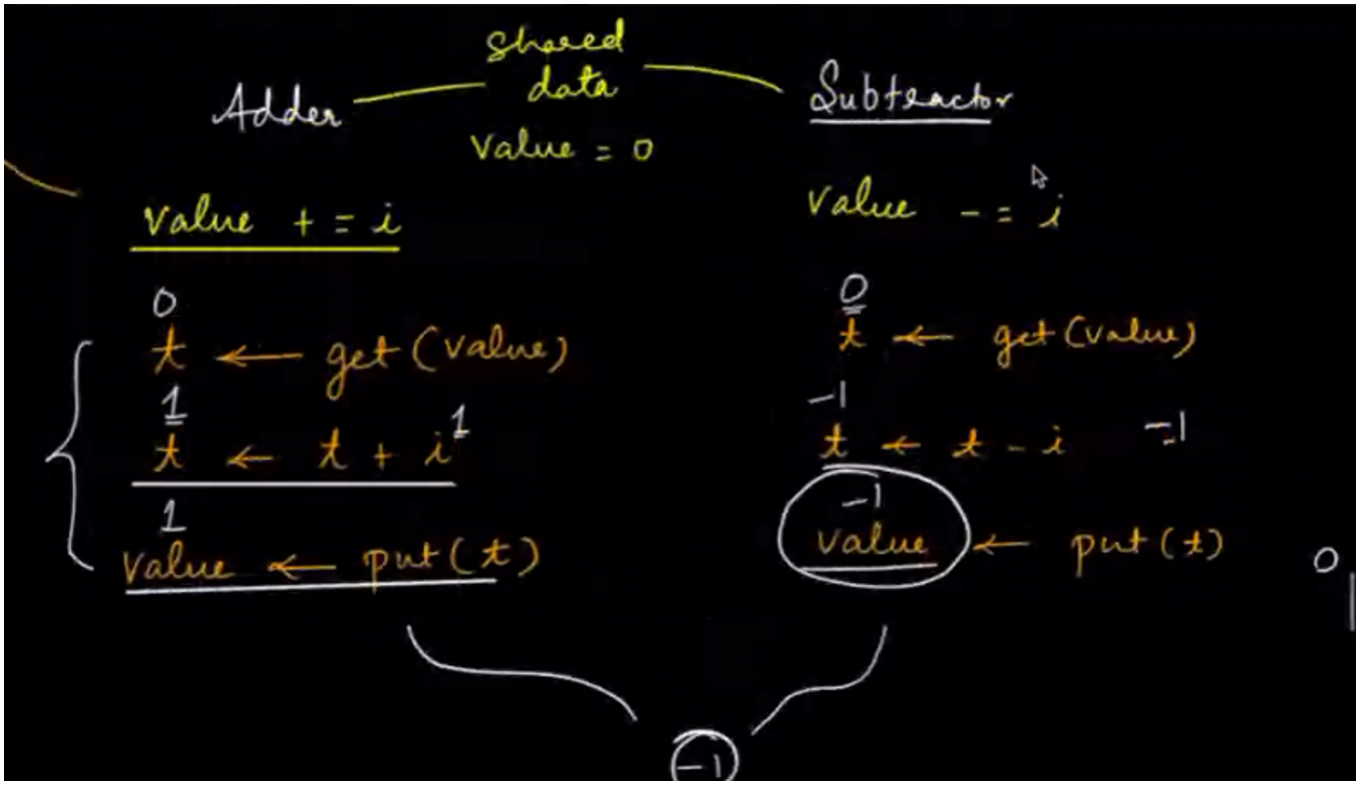


Fix return type to void in adder and subtractor.

Unsynchronised code to implement adder and subtractor using threads.

This code can results in wrong value. So we need to synchronize the code.





https://github.com/learningWithUmang/LLD_May24_Batch/tree/main/src/main/java