1. [16 marks] Consider the following Java implementation for a banking application that facilitates the transfer of money between two accounts.

import java.util.Scanner;

class BankApp {  
static void transfer(Account source, Account target, double amount) {

source.withdraw(amount);

target.deposit(amount);

}

static double getAmount() { System.out.print("Enter amount to transfer: "); return new Scanner(System.in).nextDouble();

}

public static void main(String[] args) {

Account s = getAccount();  
Account t = getAccount();  
double amt = getAmount();  
transfer(s, t, amt);

System.out.println("Transfer successful");

}

// getAccount and other methods omitted }

class Account {  
private double balance;

Account(double balance) {

this.balance = balance;

}

void withdraw(double amount) { this.balance = this.balance - amount;

}

void deposit(double amount) { this.balance = this.balance + amount;

}

// other methods omitted }

You may assume that the functionality for getting accounts to initiate the transfer has been handled correctly. This question focuses only on the transfer of money between two valid accounts.

By employing good OOP design principles, rewrite the BankApp and Account classes to include the following:

* Check that the transfer amount is greater than zero.
* Check that the transfer amount is within the balance of the withdrawal account.
* Ease of inclusion of different types of accounts, each with a specific withdrawal limit. Include a SavingsAccount with a withdrawal limit of $1000.
* Terminate the transfer immediately for any violations above.
* Ensure that a deposit does not follow a failed withdrawal.

ANSWER:

Abstract Class BAccount{

BAccount(double balance){

This.balance = balance;

}

Public Boolean hasAmount(double amt){

Return (balance >= amt);  
 }

Public abstract double withdraw(double amt)

Public void deposit (double amount) {

this.balance = this.balance + amount;

}

}

Class Account extends BAccount{

Account(double a){

Super(a);

}

Public double withdraw(double amt){

If (amt<=0||!this.hasAmount()){

Return 0;

}Else{

This.balance -=amt;

Return amt;

}

}

}

SavingsAccount extends BAccount{

Double limit

SavingsAccount(double amt,double limit){

Super(amt);

This.limit = limit;

}

Public double withdraw(double amt){

If (amt<=0||!this.hasAmount()){

Return 0;

}Else if (amt>this.limit){

Return 0;

}else{

This.balance -=amt;

Return amt;

}

}

}

Class BankApp{

static void transfer(Account source, Account target, double amount) {

double x = source.withdraw(amount);

if (x>0){

target.deposit(x);

System.out.println("Transfer successful");

}else {

System.out.println(“Transfer failed”);

}

}

static double getAmount() {

System.out.print("Enter amount to transfer: ");

return new Scanner(System.in).nextDouble();

}

public static void main(String[] args) { Account s = getAccount();  
Account t = getAccount();  
double amt = getAmount();  
transfer(s, t, amt);

}

2. [16 marks] The following program shows a typical setup for a system that comprises

a console that handles the input/output, and the (business-)logic part of the system. import java.util.Scanner;

class Console {  
private String id; private Logic logic;

Console(String id, Logic logic) {

this.id = id;

this.logic = logic;

}

void start() {

Scanner sc = new Scanner(System.in);

String command;

do {

System.out.print("Enter a command: ");

command = sc.next();

logic.invoke(command, this);

} while (!command.equals("exit"));

}

void feedback(String mesg) {

System.out.println(id + ": " + mesg);

} }

class Logic {  
void invoke(String command, Console console) {

// do something based on the command

console.feedback(command + " executed");

}

}

class Main {

public static void main(String[] args) {

Logic logic = new Logic();  
Console console = new Console("main", logic);

console.start();

}

}

In particular, when a command is entered via the console, the logic component invokes the command and initiates a feedback call to the console. In the above design, the Console class is dependent on the Logic class (via the private instance field), while the Logic class depends on the Console class (via the parameter in method invoke).

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This establishes a cyclic-dependency, which makes isolation and testing of individual components difficult. A sample run of the above program is given in the following.

Enter a command: load main: load executed Enter a command: store main: store executed Enter a command: exit main: exit executed

Redesign the system to remove the cyclic dependency while maintaining the feedback call. Moreover, the system should facilitate the inclusion of other secondary consoles that receives the same feedback as the primary console. A sample run is given below where input is provided via the primary console, and feedback is provided to both primary and secondary consoles.

Enter a command: load primary: load executed secondary: load executed Enter a command: store primary: store executed secondary: store executed Enter a command: exit primary: exit executed secondary: exit executed

ANSWER:

class Console {  
private String id; private Logic logic;

Console(String id) {

this.id = id;

}

void start() {

Scanner sc = new Scanner(System.in);

String command;

do {

System.out.print("Enter a command: ");

command = sc.next();

logic.invoke(command, this);

} while (!command.equals("exit"));

}

void feedback(String mesg) {

System.out.println(id + ": " + mesg);

} }

class Logic {

private static List<Console> consoles = new ArrayList<>();

public static void invoke(String cmd) {

// do something based on the command

Consoles.stream().forEach(x->x.feedback(cmd+ “ executed”))

}

Void addConsole(Console c){

consoles.add(c);

}

void start() {

Scanner sc = new Scanner(System.in);

String command;

do {

System.out.print("Enter a command: ");

command = sc.next();

Logic.invoke(command);

} while (!command.equals("exit"));

}

}

class Main {

public static void main(String[] args) {

Logic logic = new Logic();  
Console console = new Console("primary");

Console number2 = new Console(“secondary”);

Logic.addConsole(console);

Logic.addConsole(number2);

Logic.start();

}

}

3. [16 marks] Write a static method findMinMax with the signature static Optional<MinMax> findMinMax(Stream<Integer> instream)

that takes a Stream of Integer values and finds both the maximum and minimum values via the MinMax class given below.

class MinMax {

final int min, max;

public MinMax(int min, int max) {

this.min = min;

this.max = max;

}

@Override  
public String toString() {

return min + ", " + max;

}

}

Take note of the following:

• An Optional<MinMax> empty instance is returned if the input stream is empty • The steam pipeline should work if parallelized  
• You are not allowed to use any Java collections

Using the following program fragment as an example

System.out.print("From range: ");

int from = (new Scanner(System.in)).nextInt();

System.out.print("To range: ");

int to = (new Scanner(System.in)).nextInt();

Stream<Integer> instream = IntStream .rangeClosed(from, to)  
.mapToObj(x -> Integer.valueOf(x));

System.out.println(findMinMax(instream));

the sample runs are:

• From range: -123 To range: 456 Optional[-123, 456]

• From range: -123 To range: -456 Optional.empty

ANSWER:

import java.util.stream.Stream;

import java.util.Optional;

....

static Optional<MinMax> findMinMax(Stream<Integer> instream) {

Optional<Integer> min = instream.min((Integer I, Integer j )-> i.compareTo(j)));

Optional<Integer> max = instream.max((Integer I, Integer j )-> i.compareTo(j)));

return Optional.ofNullable(new MinMax(min.get(),max.get())).or(()-> Optional.empty());

}

\*\*4. [16 marks] The following depicts a classic tail-recursive implementation for finding

the sum of values of n (given by 􏰘ni=0 i) for n ≥ 0.

static long sum(long n, long result) { if (n == 0) {

return result;

} else {

return sum(n - 1, n + result); }

}

In particular, the implementation above is considered tail-recursive because the re- cursive function is at the tail end of the method, i.e. no computation is done after the recursive call returns. Using an example, sum(100, 0) gives 5050. However, this recursive implementation causes a java.lang.StackOverflowError error for large values such as sum(100000, 0).

Although the tail-recursive implementation can be simply re-written in an iterative form using loops, we desire to capture the original intent of the tail-recursive imple- mentation using delayed evaluation via the Supplier functional interface.

We represent each recursive computation as a Compute<T> object. A Compute<T> object can be either:

• a recursive case, represented by a Recursive<T> object, that can be recursed, or • a base case, represented by a Base<T> object, that can be evaluated to a value

of type T.  
As such, we can rewrite the above sum method as

static Compute<Long> sum(long n, long s) { if (n == 0) {

return new Base<>(() -> s); } else {

return new Recursive<>(() -> sum(n - 1, n + s)); }

}

Complete the program by writing the Compute, Base and Recursive classes. By making use of a suitable client class Main, show how the “tail-recursive” implementation is invoked.

ANSWER:

Abstract Class Compute<T> {

Supplier<T> sup;

Compute(Supplier<T> s){

Sup = s;

}

Abstract <R> Compute<R> sum(T n,T s);

Public T get(){

Return sup.get();

}

}

Base<T> extends Compute<T>{

Base(Supplier <T> s){

Super(s);

}

Static <R>Compute<R> sum(T n,T s){

Return this.get()

}

}

Recursive<T> extends Compute<T>{

Recursive(Supplier<T> s){

Super(s);

}

Static <R> Compute<R>sum(T n,T s){

If (n ==0){

Return new Base<>(()-> s);

Else{

Return new Recursive<>(()-> sum(n-1,s+n));

}

}

}

Class Main{

Public static void main(String[] args){

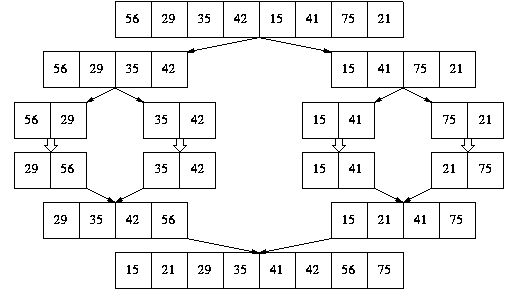
Compute<Long> sum = Compute.sum(1000, 12);

System.out.println(sum.get());

}

}

5. [16 marks] Merge sort is a divide-and-conquer sorting technique that divides a list of elements into two halves, and applies the method recursively to the sub-lists. Tradi- tionally, this sub-division is applied until a sub-list of one element, and merging of the sub-lists then takes place. However, the sub-list may be deemed small enough such that applying a more conventional sorting technique will result in the list being sorted more quickly. The figure below shows this case where sub-lists of two elements are immediately sorted, so that merging can then take place.



In the context of concurrent programming, implement the above sorting technique on a List of elements of a generic type T. Note the following:

• Set up a MergeSortTask as a RecursiveAction task from Java’s fork/join frame- work. For example, merge-sorting a List of type Integer would be invoked as

MergeSortTask<Integer> task = new MergeSortTask<Integer>(integerList); task.compute();

• Use List’s subList() method to divide the list. List<E> subList(int fromIndex, int toIndex)

Returns a view of the portion of this list between the specified fromIndex, inclusive, and toIndex, exclusive.

• Use Collections.sort() to sort a sufficiently small list. You may decide on a suitable threshold on the length of the list.

public static <T extends Comparable<? super T>> void sort(List<T> list)

Sorts the specified list into ascending order, according to the natural ordering of its elements. All elements in the list must implement the Comparable interface.

• Abstract the merging of sub-lists as a separate merge method  
void merge(List<T> list, List<T> leftHalf, List<T> rightHalf)

ANSWER:

Class MergeSortTask<T extends Comparable <? Super T>> extends RecursiveTask<T extends Comparable <? Super T {

Int Threshold;

List<T> list;

MergeSortTask(int threshold, List<T> list){

Threshold = threshold;

List = list;

}

Public List<T> Compute(){

If (list.size()<=threshold){

Return Collections.sort(list);

}else{

Int divider = List.size()/2;

MergeSortTask<T> Left = new MergeSortTask(threshold,list.subList(0,divider)).fork();

MergeSortTask<T> Right = MergeSortTask(threshold,list.subList(divider,list.size())).fork();

List<T> r = right.join();

List<T> l = left.join();

return merge(this.list,l,r);

}

Public void merge(List<T> list, List<T> leftHalf, List<T> rightHalf ){

List<T> Merged = new ArrayList<>();

While (Merged.size()<list.size()){

If (left.isEmpty()){

Merged.addAll(right);

}else if (right.isEmpty()){

Merged.addAll(left);

}

If (left.get(0).compareTo(right.get(0)){

Merged.add(Left.remove(0));

}else{

Merged.add(right.remove(0));

}

}

This.list = merged;

}