数据结构与算法
实验报告

第二次

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目录

实验 1.....2
1. 题目.....2
2. 数据结构设计.....2
3. 算法设计.....3
4. 主干代码说明.....4
5. 运行结果展示.....5
6. 总结和收获.....6
7. 参考文献.....6
实验 2.....7
8. 题目.....7
9. 数据结构设计.....9
10. 算法设计.....10
11. 主干代码说明.....11
12. 运行结果展示.....12
12.1 过程性结果.....12
12.2 最终结果.....12
13. 总结和收获.....21
14. 参考文献.....21
实验 3.....22
15. 题目.....22
16. 数据结构设计.....22
17. 算法设计.....23
18. 主干代码说明.....23
19. 运行结果展示.....24
20. 总结和收获.....41
21. 参考文献.....41

实验 1

1. 题目

回文串就是指不论正读还是反读都是一样的字符串。比如以下都是回串：”radar”、”able was ere saw elba”，另外，如果我们做一个可以忽略文本串中的空格的话，那么下面串也是回文串：“a man a plan a canal panama”。

题目任务：

1.要求使用递归思想，编写一个函数 testPalindromeByRecursion，该函数用来判断给定的字符串参数是否是回文串，如果是则返回 true，否则返回 false。

2.要求使用栈数据结构，将 1 中编写的程序转换成非递归函数，函数名为：testPalindromeByStack，该函数用来判断给定的字符串是否是回文串，如果是则返回 true，否则返回 false。

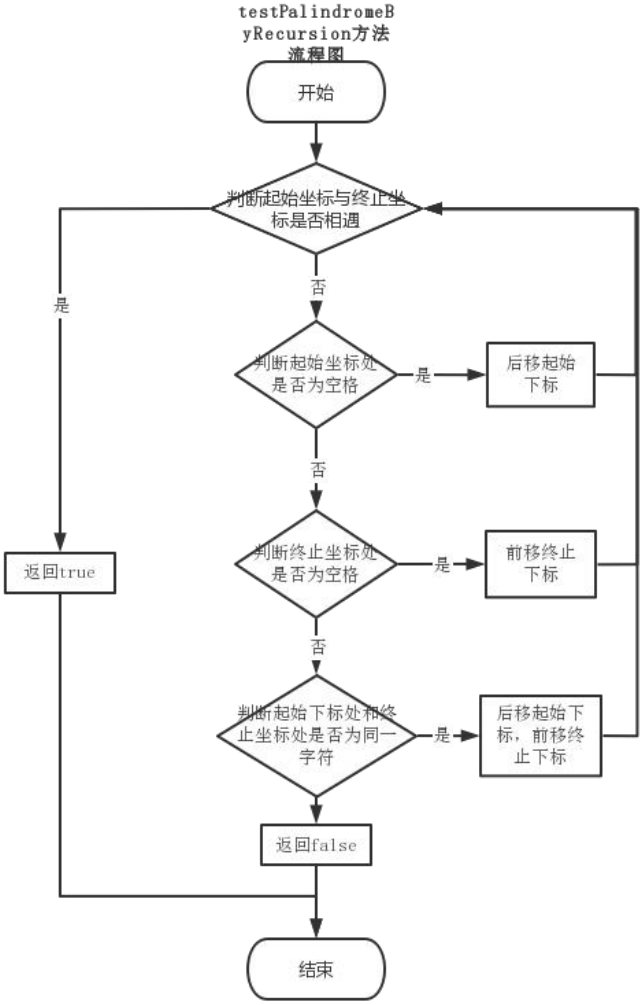
注：本实验中使用的栈和队列都只能使用自定义的数据结构，以下同。

2. 数据结构设计

设计一个栈，储存字符串。

```
public class Node {
    private char element;
    private Node below;
}

public class MyStack {
    private Node top;
    private int length;
}
```

3. 算法设计



testPalindromeByStack 方法：

将字符串中的除了空格的字符输入两个栈中，将第二个栈中的元素弹入第三个栈中，比较第一个栈和第三个栈中弹出的元素是否相同，若均相同则返回 true。

4. 主干代码说明

```
boolean testPalindromeByRecursion(int start,int end){
    if(end-start<1){
        return true;
    }
    if (string.charAt(start)==' '){
        return testPalindromeByRecursion(start+1,end);        //后移起始下标
    }
    if (string.charAt(end)==' '){
        return testPalindromeByRecursion(start,end-1);        //前移终止下标
    }
    if (string.charAt(start)!=string.charAt(end)){
        return false;
    }
    return testPalindromeByRecursion(start+1,end-1);          //后移起始下标，前移终止下标
}
```

```
boolean testPalindromeByStack(){
    MyStack myStack1 = new MyStack();        //原始顺序
    MyStack myStack2 = new MyStack();        //暂存栈
    MyStack myStack3 = new MyStack();        //倒序
    for (int i = 0; i < string.length(); i++) {
        if (string.charAt(i) != ' ') {
            myStack1.push(string.charAt(i));
            myStack2.push(string.charAt(i));
        }
    }
    for (int i = 0; i < myStack1.getLength(); i++) {
        myStack3.push(myStack2.pop());        //倒序存入
    }
    for (int i = 0; i < myStack1.getLength(); i++) {
        if(myStack1.pop()!=myStack3.pop()){
            return false;
        }
    }
    return true;
}
```

5. 运行结果展示

测试代码:

```
public static void main(String[] args) {
    String string = "able was  i  ere  saw  elba";
    TestPalindrome testPalindrome = new TestPalindrome(string);
    System.out.println(testPalindrome.getString()+
            " 递归结果为"+testPalindrome.testPalindromeByStack()+" 栈结果为"+testPalindrome.testPalindromeByStack());
    testPalindrome.setString("");
    System.out.println(testPalindrome.getString()+
            " 递归结果为"+testPalindrome.testPalindromeByStack()+" 栈结果为"+testPalindrome.testPalindromeByStack());
    testPalindrome.setString("1");
    System.out.println(testPalindrome.getString()+
            " 递归结果为"+testPalindrome.testPalindromeByStack()+" 栈结果为"+testPalindrome.testPalindromeByStack());
    testPalindrome.setString("12");
    System.out.println(testPalindrome.getString()+
            " 递归结果为"+testPalindrome.testPalindromeByStack()+" 栈结果为"+testPalindrome.testPalindromeByStack());
    testPalindrome.setString("123");
    System.out.println(testPalindrome.getString()+
            " 递归结果为"+testPalindrome.testPalindromeByStack()+" 栈结果为"+testPalindrome.testPalindromeByStack());
    testPalindrome.setString("12321");
    System.out.println(testPalindrome.getString()+
            " 递归结果为"+testPalindrome.testPalindromeByStack()+" 栈结果为"+testPalindrome.testPalindromeByStack());
    testPalindrome.setString("123321");
    System.out.println(testPalindrome.getString()+
            " 递归结果为"+testPalindrome.testPalindromeByStack()+" 栈结果为"+testPalindrome.testPalindromeByStack());

}
```

运行结果:

```
able was  i  ere  saw  elba 递归结果为false 栈结果为false
 递归结果为true 栈结果为true
1 递归结果为true 栈结果为true
12 递归结果为false 栈结果为false
123 递归结果为false 栈结果为false
12321 递归结果为true 栈结果为true
123321 递归结果为true 栈结果为true
```

6. 总结和收获

在写第二个方法时，刚开始节点中的两个成员分别是 element 和 precursor，后来感觉这个名字不太好，应该改为 element 和 below（这个节点下面的元素）。但是在构造方法中的传入变量名忘记改了，导致 pop 的时候 top = new Node(element, top)没有给 below 赋值，出现了空指针引用。

之后一是应该先做好全局的构思再写代码，二是改名的时候应该注意是否全都改了，尤其在传参的时候。

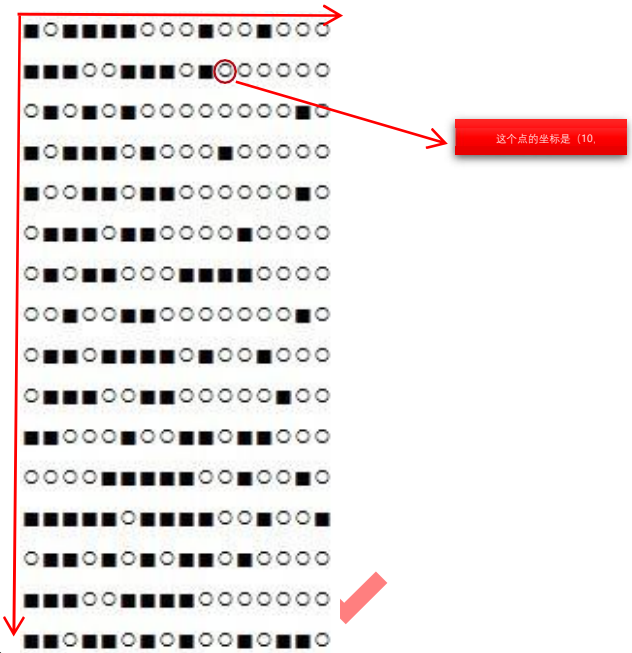
7. 参考文献

无。

实验 2

8. 题目

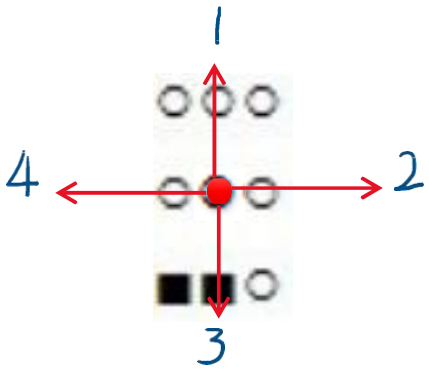
一个用 unicode 字符'■'和'○'构成的迷宫，将其存储在给定的输入文件中，其中'■'代表墙壁， 而'○'代表迷宫中可以通行的道路。给定的迷宫都是一个正方形，其中迷宫中的墙壁



或者道路都是 .

有坐标的，坐标的原点是整个迷宫的左上角，水平方向是 x 轴，垂直方向是 y 轴，如上图所示。

题目中给出探索这个迷宫的起点和终点坐标，要求能给出一个从起点到终点所构成的一个坐标点序列，该序列串起来就是所要求解的路径。为了保证路径的唯一性（不追求路径是最短），规定探索迷宫时的方向顺序为：上北、右东、下南和左西。具体示例如下：



也就是对于到达某个道路的一个坐标点时，先尝试探索北侧是否有路径可达，如果没有则考虑右侧是否有路径可达，依次类推。

实验为大家准备了四个用例，其中两个用例为测试用例(maze1.txt 和 maze2.txt，对应存放路径信息的文件是 result_maze1.txt 和 result_maze2.txt)，另外两个用例为检查作业正确性的用例。为了完成正确的测试，规定了输入和输出的数据格式，输入数据的格式主要是为了让我们知道如何读取迷宫的信息，而输出的格式是为了让我们判断所给定的路径是否是正确的路径。当四个测试用例都正确时，则说明你的迷宫探索程序是正确的。

下面是四个迷宫用例中的第一个用例数据，输入格式为：第一行是迷宫的大小；第二行是迷宫的入口点坐标（用空格分开两个值）；第三行是迷宫的终点坐标；剩余 16 行就是迷宫的方阵了。

上图中右侧的数据列是针对上面用例运行之后的输出数据（只有一部分），具体的格式为每一行都是一个用圆括号括起来的坐标对，第一行是迷宫的起点坐标，最后一行是迷宫的终点坐标， 将这些坐标按顺序串起来就是迷宫的行走路径。（注意：圆括号和逗号都是英文符号，圆括号和数字之间是没有空格的。）

题目任务：

要求使用递归思想，编写一个函数 mazeTravelByRecursive，该函数用来读取迷宫数据，然后输出正确地走迷宫的序列。

要求使用栈数据结构， 将 1 中编写的程序转换成非递归函数， 函数名为：mazeTravelByStack，函数的功能如 1。

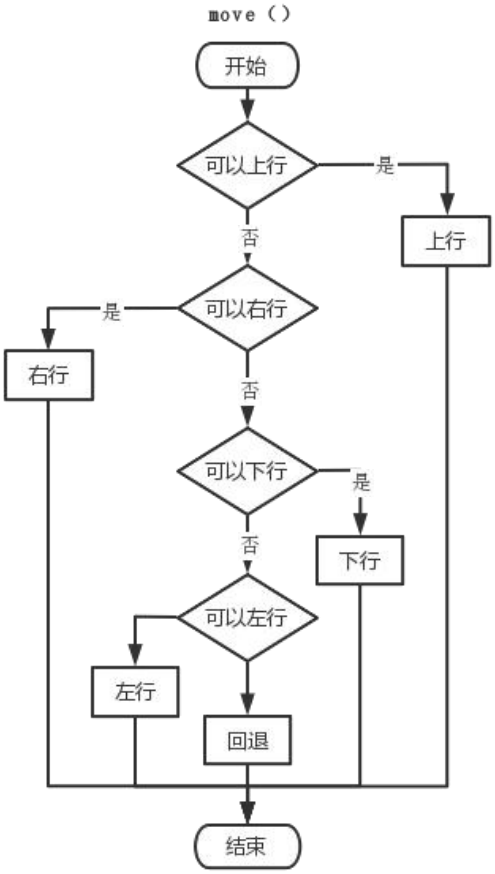
注：题目中用来代表墙和通道的 Unicode 字符的相应 Unicode 编码为：U+25A0 和 U+25CB。

9. 数据结构设计

```
public class Maze {
    private int size;
    private boolean[][] map = new boolean[10000][10000];//墙表示为 true，路表示为 false
    private Player player = new Player(this);
}

public class Player {
    private int x;
    private int y;
    private int destinationX;
    private int destinationY;
    private Maze maze;
    private Direction direction=Direction.LEFT;
    public MyStack records = new MyStack();
}

public enum Direction {
    RIGHT,LEFT,UP,DOWN
}

public class Position {
    int x;
    int y;
}

public class MyStack {
    Position[] positions = new Position[100000];
    int top;//栈顶的上一个
}
```

10. 算法设计

```
public void go(){
    try {
        将现在的位置压入栈中;
        while ((x,y)!=(destinationX,destinationY)){
            move();                          //move 直到到达终点
        }
        for (int i = 0; i < records.top; i++) {
            print(records.positions[i]);     //弹栈
        }
    }catch (NullPointerException e){
        print("no path");                    //如果出现异常，输出“no path”
    }
}
```



11. 主干代码说明

```
public void go(){
    try {
        records.push(new Position(x,y));                    //将现在的位置压入栈中
        while (x!=destinationX||y!=destinationY){
            move();                                         //move 直到到达终点
        }
        for (int i = 0; i < records.top; i++) {
            System.out.println(records.positions[i]);       //弹栈
        }
    }catch (NullPointerException e){
        System.out.println("no path");                      //如果出现异常，输出“no path”
    }
}


public void move() {
    if (!maze.isUnreachable(x, y - 1)) {                    //上
        records.push(new Position(x, y - 1));
        y--;
        maze.getMap()[y][x] = true;
    } else if (!maze.isUnreachable(x + 1, y)) {             //右
        records.push(new Position(x + 1, y));
        x++;
        maze.getMap()[y][x] = true;
    } else if (!maze.isUnreachable(x, y + 1)) {             //下
        records.push(new Position(x, y + 1));
        y++;
        maze.getMap()[y][x] = true;
    } else if (!maze.isUnreachable(x - 1, y)) {             //左
        records.push(new Position(x - 1, y));
        x--;
        maze.getMap()[y][x] = true;
    } else {
        Position tempPosition = records.pop();              //回退
        x = tempPosition.x;
        y = tempPosition.y;
    }
}
```

12. 运行结果展示

12.1 过程性结果

测试 2 运行结果如下：

```
D:\Javaaaa\数据结构与算法第二次作业\experiment02\out\production\experiment02 com.company.Main
Exception in thread "main" java.lang.NullPointerException Create breakpoint : Cannot read field "x" because "tempPosition" is null
    at com.company.Player.move(Player.java:101)
    at com.company.Player.go(Player.java:72)
    at com.company.Main.main(Main.java:7)

Process finished with exit code 1
```

参考结果文档可知，此时没有路径可以到达终点。
解决方法：加入一个 try catch 语句，当抛出异常时打印”no path”
结果：

```
D:\Javaaaa\ruanjian\bin\java.exe "-ja
 .jar=52309:D:\Javaaaa\ruanjian\ideaI
 D:\Javaaaa\数据结构与算法第二次作业\expe
no path

Process finished with exit code 0
```

12.2 最终结果

测试 1

(15,3)
(15,2)
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测试 2

no path

测试 3

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测试 4

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经过检验，测试 1 与测试 2 与结果相同。

13. 总结和收获

在这次实验中，先整体构思了再去写的代码，感觉思路要比之前有一点想法就写代码要清晰，但是刚开始的想法是先把胡同的地方找出来，然后不去走这些地方。这个时候并没有把胡同找全，有一些区域没有被找到。感觉这个其实属于算法的优化，在实践的时候还是应该先把程序写出来，再进行优化。

退行的方法使程序具有了灵活性，在今后的编程中可以借鉴。

14. 参考文献

无。

实验 3

15. 题目

回文串就是指不论正读还是反读都是一样的字符串。比如以下都是回文串：”radar”、”able was i ere saw elba”，另外，如果我们做一个可以忽略文本串中的空格的话，那么下面串也是回文串：“a man a plan a canal panama“。

题目任务：

1. 要求使用递归思想，编写一个函数 testPalindromeByRecursion，该函数用来判断给定的字符串参数是否是回文串，如果是则返回 true，否则返回 false。

2. 要求使用栈数据结构，将 1 中编写的程序转换成非递归函数，函数名为：testPalindromeByStack，该函数用来判断给定的字符串是否是回文串，如果是则返回 true，否则返回 false。

注：本实验中使用的栈和队列都只能使用自定义的数据结构，以下同。

16. 数据结构设计

```
public class Node {
    public int[] elements = new int[10000];//倒序存储
    public int lenght;
    Node next;
}

public class MyStack implements MyStackInterface{
    public int[] elements = new int[100000];
    int top;//栈顶的上一个
}

public class MyQueue implements MyQueueInterface{
    Node head;//头节点
    Node tail;//尾节点
}

public class RadixSort implements RadixSortInterface {
    int radix;
    MyQueue myQueue;
    int maxLenght;
    String filename;
}
```

17. 算法设计

```
public void sort(int maxLenght) {
    for (int index = 0; index < maxLenght; index++) {          //从第 0 位到最高位排序
        radixsort(index);
    }
}

public void radixsort(int index) {
        while (!myQueue.isEmpty()) {     //当队列中的元素不为空时，出队到各自的桶中
        mySortQueues[tempNode.elements[index]].enqueue(myQueue.dequeue());
    }
    for (int i = 0; i < radix; i++) {              //将每个桶中的元素出队
        while (!mySortQueues[i].isEmpty()) {
            myQueue.enqueue(mySortQueues[i].dequeue());
        }
    }
}
```

18. 主干代码说明

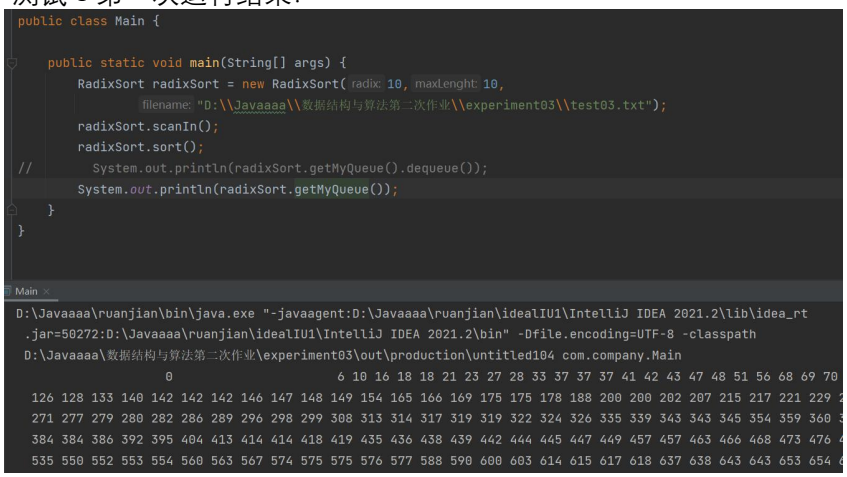
```
public void sort(int maxLenght) {
    for (int index = 0; index < maxLenght; index++) {          //从第 0 位到最高位排序
        radixsort(index);
    }
}

public void radixsort(int index) {
    MyQueue[] mySortQueues = new MyQueue[radix];          //创建基数个桶
    for (int i = 0; i < radix; i++) {
        mySortQueues[i]=new MyQueue();
    }
    while (!myQueue.isEmpty()) {              //当队列中的元素不为空时，出队到各自的桶中
        Node tempNode = myQueue.dequeue();
        mySortQueues[tempNode.elements[index]].enqueue(tempNode);
    }
    for (int i = 0; i < radix; i++) {              //将每个桶中的元素出队
        while (!mySortQueues[i].isEmpty()) {
            Node tempNode = mySortQueues[i].dequeue();
            myQueue.enqueue(tempNode);
        }
    }
}
```

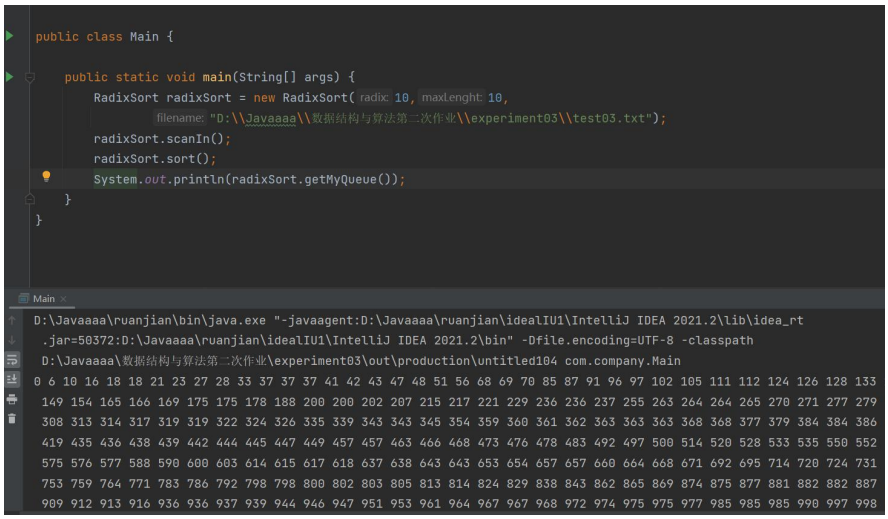
19. 运行结果展示

19.1 过程性结果

测试 1 第一次运行结果：

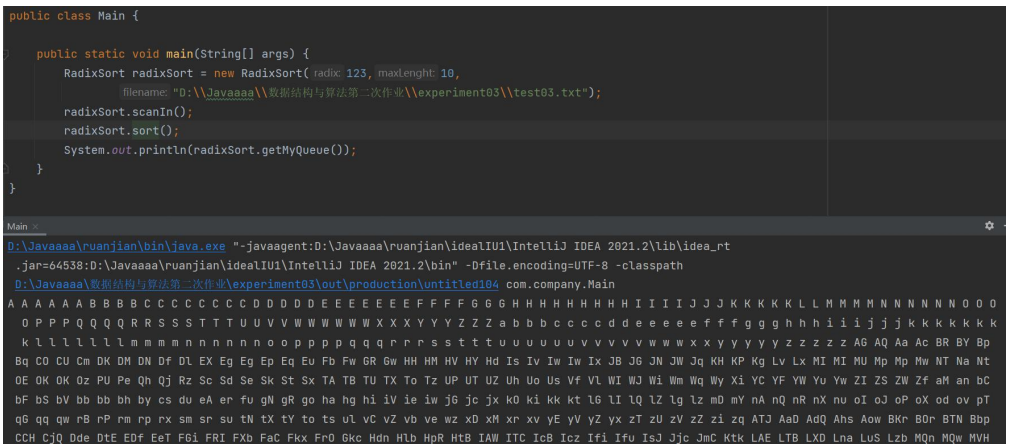


单独打印队列中元素出队的结果可知，Node 的 ToSring 方法出现问题，在 Node 中储存的元素长度为 0 时，转换为了一个空格”“，修改后重新运行得到：



19.2 最终结果

如图：



测试 1

0 6 10 16 18 18 21 23 27 28 33 37 37 37 41 42 43 47 48 51 56 68 69 70 85 87 91 96 97 102 105
111 112 124 126 128 133 140 142 142 142 146 147 148 149 154 165 166 169 175 175 178 188
200 200 202 207 215 217 221 229 236 236 237 255 263 264 264 265 270 271 277 279 280 282
286 289 296 298 299 308 313 314 317 319 319 322 324 326 335 339 343 343 345 354 359 360
361 362 363 363 363 368 368 377 379 384 384 386 392 395 404 413 414 414 418 419 435 436
438 439 442 444 445 447 449 457 457 463 466 468 473 476 478 483 492 497 500 514 520 528
533 535 550 552 553 554 560 563 567 574 575 575 576 577 588 590 600 603 614 615 617 618
637 638 643 643 653 654 657 657 660 664 668 671 692 695 714 720 724 731 735 736 737 743
744 746 753 753 759 764 771 783 786 792 798 798 800 802 803 805 813 814 824 829 838 843
862 865 869 874 875 877 881 882 882 887 891 891 895 900 902 908 909 909 912 913 916 936
936 937 939 944 946 947 951 953 961 964 967 967 968 972 974 975 975 977 985 985 985 990
997 998 1000 1002 1003 1017 1018 1019 1020 1031 1031 1033 1037 1041 1050 1054 1058 1063
1070 1077 1079 1082 1084 1084 1086 1087 1087 1089 1096 1097 1098 1100 1103 1103 1109
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测试 2

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测试 3

A A A A A A B B B B C C C C C C C C D D D D D E E E E E E E F F F F G G G H H H H H H H H H I I I I J J J K K K K K L L M M M M N N N N N N O O O O P P P Q Q Q Q R R S S S T T T U U V V W W W W W X X X Y Y Y Z Z Z a b b b c c c c d d e e e e e f f f g g g h h h i i i j j j k k k k k k k k l l l l l l l m m m m m n n n n n n o o p p p p p q q q r r r s s t t t u u u u u u v v v v v w w w x x y y y y y z z z z z AG AQ Aa Ac BR BY Bp Bq CO CU Cm DK DM DN Df Dl EX Eg Eg Ep Eq Eu Fb Fw GR Gw HH HM HV HY Hd Is Iv Iw Iw Ix JB JG JN JW Jq KH KP Kg Lv Lx MI MI MU Mp Mp Mw NT Na Nt OE OK OK Oz PU Pe Qh Qj Rz Sc Sd Se Sk St Sx TA TB TU TX To Tz UP UT UZ Uh Uo Us Vf Vl WI WJ Wi Wm Wq Wy Xi YC YF YW Yu Yw ZI ZS ZW Zf aM an bC bF bS bV bb bb bh by cs du eA er fu gN gR go ha hg hi iV ie iw jG jc jx kO ki kk kt lG lI lQ lZ lg lz mD mY nA nQ nR nX nu oI oJ oP oX od ov pT qG qq qw rB rP rm rp rx sm sr su tN tX tY to ts ul vC vZ vb ve wz xD xM xr xv yE yV yZ yx zT zU zV zZ zi zq ATJ AaD AdQ Ahs Aow BKr BOr BTN Bbp CCH CjQ Dde DtE EDf EeT FGi FRI FXb FaC Fkx FrO Gkc Hdn Hlb HpR HtB IAW ITC IcB Icz Ifi Ifu IsJ Jjc JmC Ktk LAE LTB LXD Lna LuS Lzb MQn MQw MVH MVb Mvb Mvw NAt NNE NUl NYJ NkX OLb OdH OpL PHO PKb PSH Qzs RDq RDt RGS RJp RWv RbE RgA RhR RvX SAG SSg SdD Stu TBR TIj TMU TNA TOo TSw TXs TgB Tiq UEZ UYD UaP Ujx Urx VCc VZa Vgn WIB WPx WXB WYQ Wco XEn XRy XVh XXP XYd XoK YBr YKD YQb YQt Yjm Ywi YxU Yyu ZAo ZCe ZQc ZRj ZqJ aQC aQP aXs bFQ bWN bqM cUL cYq ccc cpu dRb dTk ddD deT dwo dyB dyo eCy eEp eJX eMH ebC eyz fCw fEi fNK fbm fel gaj ggS gni hGc iGd iMT icM jIw jSj jUB jog jxw kPn kQd kRG kTh ktt leO lil mAi mKJ nDt nSZ nar nmR noA oFc oTP oYB obF ojg oyT pHS pKt pdS ppX qNT qRK qTA qbX qfG qkH qzB qzW rCM rQj rZU roI rqi sGF sLm tAt taL tdn tgE tkX tmj uVK uYW uaT ucC ugE vAo vFa vHi vMM vOj vTW vke vle vmO wEh wRt wSv wqV wuT xRN ySz yVU yhU yxv yyG zOW zWW zag zeP ztX zwr zzQ AGGs AeTX AoMy Awqo BJdM BaUB BfOP BoAU CGga CMLW ChAL DFwv DRKs DiLm EAjv ENOv EblU FEPZ FGHx FJud FOEE FUlz FdDK FdmF Fyxi FzbC GCiJ GKNh GieD Gmjy GrOM HSNX Hece IAGi IGrC ILMf IQij IldU JIPB JUTu JepH KGbE KUkY KdgE KiEQ KkAf KyHk LBGd LCvk LJZJ LWeh LXRp LYIZ LZOU LlrN LpYT Ltpb MFyb MQeZ MZnr MlFJ MziN NFqV NPQF NQnT OAaP OChA OMNY ONRU OSSt QKlB QtiD QxHE RBEe Rehb RlJf SKed SKfJ SRmo SaKp Sxup TIiZ TOGy TUfA TgIA ULAL UptM UtQw VBJe VIJK VTao WEQm YBqG YElC YRgZ YjiM ZAUG ZDqo aWem adsX akyt aoGu bCmC bNER bWIw bWMl bdgX cALW cHfI cLpO cbDa cpEC ctqG ctqp dOkM dmJU eAOj eDdC eHXj eOYU eaME elOT fCwT fRjZ fRne fUIn gTOk gdAQ hKEm hWRN iAbr iBEB iNUI ibXd ilHt imuU jPLx jehh jtDf kXnS kZxc kiOF kleG lQpi laef lgxX lrNb mHyQ mOkh mQpE mdCs mdTo nKZA nKuq nNKu nQjM nhAA nqzj okEk pAzx pHoy phni pkno psJu qeKo qnXA qnpc qpfp qxTN rAQM rOCj rcRt rnBi rnEo rnnP sNyY sXpN sZLU sbOG snvq tEQR tRyE thNQ tnQz tyEe uEjt uPiB uTFy usqx vNyB vOQo vSlU wIda wNbw wPuj wUgZ wcex wgpK wkyR wzxX xSnV xUjf xctm xesz xwJU yqtf yxKh zBmJ zKVw zWUV zcpq zmGC zpUG zpoX zsHl APZLe AxQvc BRVvc CDhCS CIPew CSJFJ CzKoH

DBgOh DPTIf DSFOq DUmMg EEMIE EtNwZ FBYVS FGfOY FZHFp FavxO FbkPa Fnyas GAPEW GSVMa GiolQ GnRjT GqyWh HFrRZ HnmXx IFVAx IQxmj IUOmH JGVzd JfYMk KBwdk KFrkK KFvLy KRJbw KTMBz LGvVV LIyzo LWGlQ LsapD MbnOq MqBrQ MyEPG NAIeB NgSgo NrFlL OeeCG OgpTH PEOpK PPcOd PUJNP RUIyj RbjCY SRvkB SdGNN TjaEx UMgrD UtdPP VFEWB VUKva VZlKy VrFjq WVKSc XfOpN XiSHo XpfLI YEXhm YVDae YsArC YtTlm ZRnVK ZZNdf ZZgkX abPzv abiMK agtxu ajmKb anuHi arjJZ bFAID bcVeD bdErp beyvb bpDBg cMRvp crSFr ctCWs dmjKn eRapW eWSMT eeMSE fASyD fEyPH fHPYY fIoNg fcZgm gTDSz gdGiR grwPQ iCnXI iZaNc inQNK irrMB ivoOy jBMSf jWNRr jqTlw kzZIU lQJPS lWpNy lpHVq mDoyA mJfMZ mOUTL mZsEC meTKA meVkh mgpZT mwCos nGEig nGfoR nUpOm nsrmF oNYHl ohQCL onPtq oxXgY oylDp ozQPM pBTmN pCOWQ pwAhk qWqHg qdXab qjkuS qqrtP rDOTY rSMOH rWcGS rWgzv rdCRQ sZLkK sahik syluo tCicl tbMSP teywC tosdJ uBtNe uJpDP uKxWW uLFiQ uOwXV ukhCT vUBbJ vWQFJ vvXFw wFNlC wVybF woEBu wpGJi wzwAE xDeqb xPpnb xXHLe xqHDK yFIcG yftqZ ylJnB yxYNi zEhOW zMkgq zZblz zzkRs AEkRHw AGJirt AWtynC AxKQmD BEvxJY BUKBdD BfdGOZ BxVMir CImoiE CqBbka DMTypn DOCKXx DYiYUg DheLtU DooVSn ELPfzM EMqAdX EbiFIG EcXWTn ElgQJw FCimgP FePtyU FkVTIq FwMHiy FwqzlT FzWuEX GMKNDs GTDmYv GjLpFz GtnVDg GxzvxO HOYUro HkuxeC IYEqCX IhzUYI IqzzNB IyDUHJ JaaZlX JnRiuX KbSsmJ KiMUmQ KmHVQv KzdIgc LwMHvx MphJXh NKvpTl NNCqwE NULROD NapxVP OnJVkP OvdTbh PQeFkY PadpWG PlrxSi PwCoau QYycvH QiVgwd RBQaMC RDvQaw RGwhti RHpByE RcRwlG ScgApR SujZdf TCaEHD TrUBnU UGcBvM UOKmij Ubipig UyNPaj VSmAbg VfoTea VrpPEe WFJhtg WekYad WiQFEk WyEeYj XOdFbJ XjbNxQ XnsMyE YAGiWm YHqgZj YYcJEJ YiGhYE YsOJRw ZdCDYy ZhhmaM ZyheFh aZgVGl atspOH bWaloc cFfDtd cTTeHx dFmUZD dFuwen dbJMsZ dnZgHc dvGQtp dviUAd eZLPgB elkHWs fPQMvd freIfV gKYjDK gfqrPX ggtnLS gpysPZ hbHeSs hxYodH hyGCve iBjipW iBvSoh imLOSY jTKNUT jhHSKb jkbuax jrPBqQ jzRosh kZGZRd kbBOJe kmVUeX lJcVXy lTubTb lfDqUl lfIuZN lmhXMl mNnwBu nCHmtB nFZYBL nXNKMt niTEtD njWxJU nkREFD nmFaID oCNunp pFzZpK pPTGIg pPyeLi pjmgYY psMswg qKoACV qeEFTs rHZZkU rPriVq raYQNW rapvVD rhDagR rtUUqC rwEyiJ rypIpU rzmGVx sCFFKj tKIjJb tYyENm tsKgmU tuPpIr uyYJLR vkFkSi vpKFnS wCNyTb wYcXFy wlNctY wxsrrf xLYKwj xUbBIg xbLGui xeTOkP xiaUIA xtZCIn xwKnaU xyLGJd zKocYT zbxPCa zdubpz ALZvEFw AUlwBDd AfCddQL AwQzPSe AzadRKA BBNHRXb BHwFuNB CUWFUDm CZGztIv CaXGrXd CdKxnwq DBNDLnb DCDbNii DyfDMrl EBvKbRw EGyxlIz EKnLYAv EgocnhY FIylfWi FSSPHmh FboBqZk FnduVWd FwjqJxJ FyOHtza GEoFmhl GJJnbhe GwNcYiJ HMIwNIR HPgwNye HwEBxmC IGRPEOI IGbyQvT IViCsDa IiHSwBT IorFEuy IstpCZT JDCEfmH JIFSLzx JNJJyOp JOEGEFf JTDJjvL JnhkqXw KGkYncT KOKUNkD KQNYkgY LGSwRzh LVfpKpZ LdVtjTK LksudZC LlpZPCh MBVBEaP MdYbsmz MfyXVJI MgZZAAy MyMvNWh NCeQxBQ OIYDnWo OSaXVQh OcHypCL OqXeRfF PPbopjE PXMWXMp QPCRTGO QdaAwyh RByVgVc RJUpkBU RVbmwJu RYZuKIH RmWyVJA RsZlQaF RvnGRJD SFNhMMz SIJWVKn SReoFCs SSAAAPw SeXumyG SeZAAap TAiZHeW TToXuTW TnVDTge TrNRDVM UYrdYEO VUyEIJg VxOqgQD WGBlfOj WdIkyrE WuZeXZn WwZTjMG XKmCBKT YIpTxDD YKDArbI YQNbJJV YRiZeiz YsXvrkZ ZMBduSp ZPelOaA aPWyZxH bgVPSLy bkOVhcq blDSLgy cHqtsiZ cTKWCbj dYfeRUo doZOWhm duQdmZu eCxusBC eYLgZdr eocbqfu fLxBDJC fcSTOXr feEoqzf fxqoLyz gErhKkb gGVdSZX grOALEe gtXnBNy gzmnEZY hAFAhNl hARmmUG hCHzAhj hLSoJuS hYDrVBc hawfuiw hiafIJE iADdqEb iJdRAGl iQtPUgp iQvBxJW iYSBTEE idLBGMl

igfbswB iygRNKF izJMweA jyiHyRQ kIwMNXQ kOEQlOj ksnvGmT lIsclSD ljLPvst mdoJlUM npupBuo oTgVdei pAtYlfc pBMRrGY pFbZNdj pTHfeBE pekCLSA pzVTPLQ qMlwGRo qPJDgMJ qSxwMwV qeiEMwi qhepoAB qlNFibN qqjVyKh qwrEOKm rQfmsWs rkPGvsw rkWSRQF sBbKsQY sKWobqR sUJbOCB suZtcDD tDxJEzm tTsCTWm tUPUkDb tVsRVVQ tXJWjwC tbiWbLg tcbYcNT tvEfMJY uLCZDRo uLlKyQy uVaZFha ujsudCu uqbHRJd uxBzwQt uxnoBpx vmFPilY vquccfR wULxNjy wWARuHS wdoeVzz xfCpQfD xmfGsUT xuJUgMM ydIKfTf yojrtAb yvaOjIS zAZzCzs zIBuOqT zNYSNWK zWHVlEs zgiYdyQ ABispEWO ANqCjZgV AdGkmPJE AzneAjNO BLRXGkdU BSCyMxAb BYSBHdMW BsolVCXt CBeLhxxs CGdOoMwO CcSrXovQ CoPHqXoT CyeddKlX DEeKgljm DPJcoZmj DZMxRVqb DbfJCIpi DjEyQgXH EPbiXsCG EYkTgLLB EeRtgzQP EgEBRxZt EhubzHTp EjZlRBFu EoZholqT EupcDfMg FAuVOsAA FjScGDjd FktnvEFu FlFQHFHp FyCKrpVB GJlNYLyQ GMfKdnTH GQXmPDSa GXxvBtXZ HHSSCYBu HNOwyzhg HYBrYdJz HYQDEpXu HxVVpmbV HyfyREaw IsNJzVwY JLEPvrGP JNMvpUHh JPPtOarc JSiMENRg JSpyaKfx JcIlGHjS JcRUTXAz JhosAPDo KCOzpwPO KTaNkjvb LflqVoOB LjgisSlH LnrLADSM LtRfTNGh MAhpyHzq MNGIJxfc MOiWAbJz NsULRphC NxLMUQEp NxlWuoCH OVujQqfP OWVdJRRV OwpIwMyQ PYWaxFHz PawANxhT PeXdXwhg PfTfOOCb PiJCsGZR PvZxABEN RCrFJvPf RFMdnGCa RFSYFJDq RQltkzrf RRJpoERP RdtdpJAI RtocBtOK SFqZmUtT SZWxVUzc Shgxtftx SiNrchsb SmKwXvhh TCxcjHQn TFZwzhTz TKJpSvvn TPCkXblU TgWTSums TtNZHbWK UCUQpSCV UHEKJWPn UTVkBtZU UtdkcIAO UuDZpVqI VjfyFIll VyGOSuEC WQMImsYc WhzAeXKA WmxhMBts XXwLDdbk XbgexeUs YHLJbIKt YfChVzHp YqKAxWsg YuotSvgR YvmLWhso Zgoitjks ZrtEmLBd aNrYzynO askdXtjH ayCevUzT bJcOFffS bPtMjqMR bbupXGgQ bkHjojLt bpvajSow cCLTwdKm cSyALpQR cZLZRedK ciuTFMpI dulSmpIW eQYWMVKU fLtKpyYD feioHnwn forrNrlQ fxkbrJuG gBcRuKmZ gMErRSZq gTXQdCXO gdmiTiyv gmPtavvU gqQEuNkX gwWUVIEO hDFgILgd hsBpEEWc iUdkvzmr iZBgMxlV iaevznCz jFmKhzUg jQMchGRg jhjVTzgv jlNNnvyy kHEebUaw kJmfiOzl kUoQbOsf kalPqrdW kptupJvy lmzjZMRo lovIhjvv mDlczgYg mFFMrOCk mvZiayBU nDygeQlS nZbnAUrb nfPTucbJ oAxfjBqy oLDRMqXg oMyIWqYm onZnmdEQ ostgXOvO pEyoqnrI pKpTUYFB pLuromOB pcjkDPIw pedYrdGu qFzSWMAE qcUSeCMZ qjnDNDlB qpBQUXvY rAuIDIzA rPIqBGUY rcElMMis rhGKpBgK rmVlCnhd rysvfVZQ sCMLNkzv sNihxhIV sUsGsyuJ snsfKXVq syCfeRwL tBukrvxG tFfVmJIP tGYWADjS vAUUMdoz vEwPttEQ vYDLnxZk wGbZyLkt wPicZtDF weZRAexV wpDDRIIz wpgdpxCH wqSIwbCk wuLJMAVI wvdmYbue xHcTrkJU xRwdJFxM xSomhWbK xxFNiKVI yCEUfkYe yGmJkSxH yKoXEcUN yMAAEAuY ykiFuzdJ yuDHdpaW zFCEWyGA zOpetkqw zWTRYwxZ zotSFBOb ztkvsUwr AaGrCHhop BOsOTJNdY BQlpAnQWh BaqcsZvDq BebYJkXBX BlFEzAqcA BpPHAwYAU CAJoQsdFP CHoqZJnLr CStHnoGcc CbMsGEoJG CcrHYucJV CfYDFiauK DKhgxAeJG DLDIAVxSR DfnqfIsIk ELCGKBrky EdcOolnME EuEKPnerp FklGXOuUK FzeEdxHFN GFEhgQxqA GYAHvYBmx GlMlPQfbD GobwAgYnu GvkakcPxS HWbwxwLPx HXnmoMRGX IMRImniCB INbsHbNCo ITdwMxngk IWYuGSXXY IhRtyQbPd IliKLkEIm IrcvUATpe IuRwQCbrX JGtsjqkgW JcitCRprK JdpAsjqkt JdrOcFqgB JkfWNaZxu JqIRMadnt KAoueeSQc KDMTIzpUq KhZSGiQtM KlgFyUXiC KqvgOxFzi LbucvULaz LoLCDovQm MSBbKKdzT MZVDhZgvv MgskEYPEX MxoJYwubs NFBMwQNeB NaqFEsZVB NjbWcLFwz OLAaCkkja OMuqSVuiJ OWLFyIeFc OWeRDqPIx PBuhUxsDe PFpsfbBye PHlRvgLxD PRoSFAsrT PzJjHaYEm QDNWqKhrP QUBBZrOZE QXAzVmFph QdkbfPCLx QpaDjaGke QxArKsPxs RCciOweRm RFWqogYcE RatfFvYOP SEmloHTcJ SNmvyuOIz SOnmmflNR SZagpqzNz SiztdZiqU

SnHQGuqco SpHBzWSvW TBGOlsDKR TRMkKEiWW TVXqLHNyk UDrpwILiT UHhqsEOLA UPySxWWCg UWNcWtkKV UuzovLLZK VmBdrIaLQ VtuLoqwGU VtyPmSyYc VvvPrrqok WGqxjEtsb WIXdhJhjm WPqJctcOd XDtFdQGVc XDzbBgJGs XtJXVAWsO YJKRbLkjT YNApHoZZX YmlaBKvFz YvLDLIDse ZBjEXsdeb ZFsUVbISp ZsNcQCDkp ZsqUhSEcK acgdXuPgv amtVhhlVQ bIxoTHRAQ bPzbJNvrk bVctIfwfl bbJaWfHWo bgOmgEIZE bjDtEJSuc cVvFDJGPN cefnmEXPX ctzYqAErV dCLWMBHxy dSktADkRV dceLvLZpL dezrreKAM doqoSuAPt dvXfdGGxk dyafBmdtd eAXYMhjRz eHjNnhgBj eUoYSWMcE eizXSxBmu eslWSscbW ewUhFAEMK eyhOYNxHl fQkwaCehi fSQvvakUl gqVGjFXMT gyrFzyPlN hNnmGXjer hTlpsycoo hUMdRCaMZ hWijzAEux hfwdAIECQ iClLZelaQ iKdcLMzVm iODYoANDc ifdByIroB itffCEnIZ jDbCNDEBt jUNjREWbc jXZpNvLEG kFKaBDLLV kJByhNDSu kRLmuyZbn kXyCyjQEW lfZjcaCmc mLQxrHHUh mMfLLfOAq mevkizfRV mfwLMoYTC mkyQanoSv njzNZxLpK oLvRYdOxP oZWRQXYQr ofcfyDHxi ouNCaNmyt pHAXQwGJI pkmVrSWur pojasCWwI pqqNFFCsR pruXaYTvX pwwmvWScs qlihrDwzn qysndeUcU rFpVaZTmM rWKDhQMqD rfghCKLFZ rtbAlAocy sDZAqMahX sIfEWciTA sdzRIqnpb tDOVIwDav uAFxBeBFb uMHBzhxZW uegBGwWPZ umJPiINNd umWGJbqhz uxEnYJJuu vQLGfMnlW vSCCqttkY vkJXBIHgx vrEiTkdhP wLjzEjwLz wXmFOERSy wZGFGCpSo wconZwcFX wiUECjQCh wyLegxlBn xGzdNhZID xNgcfuudX xRCVAtozY xhESLvEMF xsCSvEBzW xsnOpscWK yFnDnTvRZ yTldRfXhp yllMVfZjc yqJKcIAPh zIlFgkeDq zKgTGuNPn zbNLZHLtM ziIBtfWlB ziOVEOHdv zwKrzMmIp

20. 总结和收获

在编写的时候，想到测试 1、测试 2、测试 3 的思想是一致的，可以编写一个通用的程序，但是一开始就先把三种情况都包含进去的话比较困难，导致刚开始编写时有一定难度。在之后的编写中可以遵循循序渐进的原则，在有全局观念的同时，先将简单拿到问题处理，在在此基础上完成拓展。

21. 参考文献

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