CS 323_33 Programming Language: C++

Project #8 K-means Clustering

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Due Date:

Soft copy: 4/5/2020

Hard copy: 4/5/2020

**********Main**********

```
Step 0: pointSet ← given, K ← given
           changes ← 0

Step 1: randomly select k points from pointSet.
           (The selected k points will be the initial K centroids.)

Step 2: For each point, p, in pointSet, compute distance from p to each centroid
            (K of them).  So, we have K distances: d1, d2,..., dk, associate with each di is the
            label of the centroid.

Step 3: minLabel ← the label of min(d2,..., dk)

Step 4: if p's label != minLabel
               P's label ← minLabel
               changes ++

Step 5: repeat step 2 to step 4 until all points in pointSet are processed

Step 6: if changes > 2
               Compute centroid for each group,...
               changes ← 0

Step 7: repeat step 2 to step 6 until changeFlag <= 2
```

SOURCE CODE:

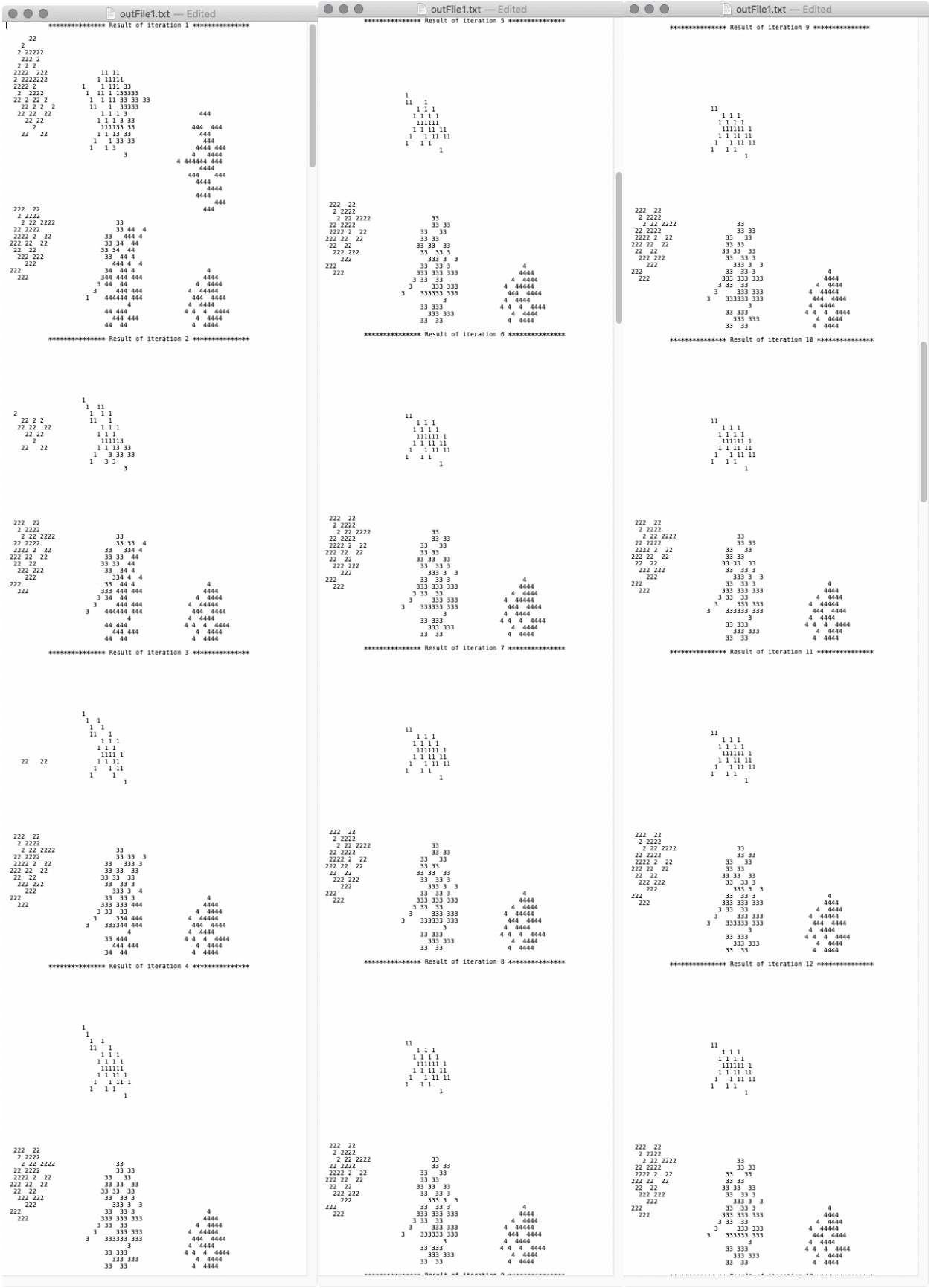
```
#include <iostream>
#include <string>
#include <fstream>
#include <cstdlib>
#include <cmath>
using namespace std;

// Data structures
class Point{
    public:
    double Xcoord;
    double Ycoord;
    int Label = 0;
    double Distance = 99999.00;
};


// Prototypes
void loadPointSet(ifstream& inFile, Point* pointSet);
void PlotDisplayAry(Point* pointSet, int** displayAry, int numPts);
void PrettyPrint(int** displayAry, ofstream& outFile, int iteration, int rows, int cols);
void kMeansClustering(Point* pointSet, int K, Point* KcentroidAry, int** displayAry, ofstream&
outFile1, ofstream&  outFile2, int numPts, int numRows, int numCols, int changes);

void selectKcentroids(Point* pointSet, int K, Point* KcentroidAry, int numPts);
int DistanceMinLabel(Point& pt, Point* KcentroidAry, double& minDist, int K);
double computeDist(Point pt, Point centroid);
void computeCentroids(Point* pointSet, Point* KcentroidAry, int K, int numPts);
void PrintResult(Point* pointSet, ofstream& outFile1, int numRows, int numCols, int numPts);




int main(int argc, char* argv[]){
    ifstream inFile(argv[1]);
    int K = stoi(argv[2]);
    ofstream outFile1(argv[3]);
    ofstream outFile2(argv[4]);

    // Variables
    // 1
    int numRows, numCols, numPts, changes = 0;
    inFile >> numRows;
    inFile >> numCols;
    inFile >> numPts;

    int** displayAry = new int*[numRows];
    for(int i = 0; i < numRows; i++){
        displayAry[i] = new int[numCols];
    }

    Point* pointSet = new Point[numPts];
    Point* KcentroidAry = new Point[K+1];
    for(int i = 0; i < K+1; i++){
        KcentroidAry[i].Distance = 0.0;
    }

    loadPointSet(inFile, pointSet);
    kMeansClustering(pointSet, K, KcentroidAry, displayAry, outFile1, outFile2, numPts, numRows,
numCols, changes);
    PrintResult(pointSet, outFile2, numRows, numCols, numPts);

    // Closing Files
    inFile.close();
    outFile1.close();
    outFile2.close();
}
```

```
// Functions

void PrintResult(Point* pointSet, ofstream& outFile2, int numRows, int numCols, int numPts){
    outFile2 << numRows << " " << numCols << endl;
    outFile2 << numPts << endl;

    for(int i = 0; i < numPts; i++){
        outFile2 << pointSet[i].Xcoord << " " << pointSet[i].Ycoord << " " << pointSet[i].Label
<< endl;
    }
}

void computeCentroids(Point* pointSet, Point* KcentroidAry, int K, int numPts){
    double sumX[K+1];
    double sumY[K+1];
    int totalPt[K+1];
    for(int i = 0; i < K+1; i++){
        sumX[i] = 0.0;
        sumY[i] = 0.0;
        totalPt[i] = 0;
    }

    // 1
    int index = 0;
    int label = 0;



    while(index < numPts){
        //2
        label = pointSet[index].Label;
        sumX[label] += pointSet[index].Xcoord;
        sumY[label] += pointSet[index].Ycoord;
        totalPt[label]++;

        // 3
        index++;
    } // 4

    // 5
    label = 1;



    while(label <= K){ // <= K because we need K elements and we start label at 1
        // 6
        if(totalPt[label] > 0.0){
            KcentroidAry[label].Xcoord = (sumX[label]/totalPt[label]);
            KcentroidAry[label].Ycoord = (sumY[label]/totalPt[label]);
        }

        // 7
        label++;
    }


}

double computeDist(Point pt, Point centroid){
    double result = sqrt(     pow( (pt.Xcoord-centroid.Xcoord), 2)    +   pow( (pt.Ycoord-
centroid.Ycoord), 2)   );
    return result;
}

int DistanceMinLabel(Point& pt, Point* KcentroidAry, double& minDist, int K){
    // minDist = 99999.0;
    int minLabel = 0;

    int label = 1;
```

```
    while (label <= K){
        // Point whichCentroid = KcentroidAry[label];

        double dist = computeDist(pt, KcentroidAry[label]);

        if(dist < minDist){
            minLabel = label;
            minDist = dist;
        }
        label++;
    }
    return minLabel;
}

void selectKcentroids(Point* pointSet, int K, Point* KcentroidAry, int numPts){
    // creating data structure
    bool checkedPoints[numPts];
    for(int i = 0; i < numPts; i++){ checkedPoints[i] = false;}

    int index = rand() % numPts;
    // bool repeatYN = false;
    int Kcnt = 0;
    while(Kcnt < K){
        while(checkedPoints[index]){
            index = rand() % numPts;
            // repeatYN = checkedPoints[index];
        }
        Kcnt++;
        KcentroidAry[Kcnt].Xcoord = pointSet[index].Xcoord;
        KcentroidAry[Kcnt].Ycoord = pointSet[index].Ycoord;
        KcentroidAry[Kcnt].Label = Kcnt;
        KcentroidAry[Kcnt].Distance = 0.0;

        checkedPoints[index] = true;
    }

}



void kMeansClustering(Point* pointSet, int K, Point* KcentroidAry, int** displayAry, ofstream&
outFile1, ofstream&  outFile2, int numPts, int numRows, int numCols, int changes){
    // 0
    int iteration = 0;
    int index = 0;
    int doOnce = 1;

    // 1
    selectKcentroids(pointSet, K, KcentroidAry, numPts);

    while (iteration < 25 || doOnce > 0) { // 2 - 9
        doOnce--;
        // 2
        index = 0;
        iteration++;




        while (index < numPts){ // 4 - 7
            // 4
            Point pt = pointSet[index];
            double minDist = pointSet[index].Distance;

            // 5
            int minLabel = DistanceMinLabel(pt, KcentroidAry, minDist, K);
            // pointSet[index].Distance = minDist;

            // 6
            if(pointSet[index].Label != minLabel){
```

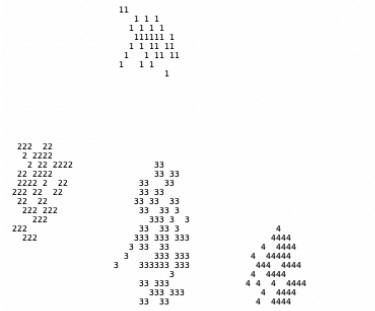
```
                pointSet[index].Label = minLabel;
                pointSet[index].Distance = minDist;
                changes++;
            }
            // 7
            index++;
        } // 8 loop



        // 9
        if (changes > 2) {
            computeCentroids(pointSet, KcentroidAry, K, numPts);
            changes = 0;
        }

        // // 3

        PlotDisplayAry(pointSet, displayAry, numPts);
        PrettyPrint(displayAry, outFile1, iteration, numRows, numCols);




    }// 10 loop

}

void PrettyPrint(int** displayAry, ofstream& outFile1, int iteration, int rows, int cols){
    outFile1 << "\t*************** Result of iteration " << iteration << " ***************" <<
endl;
    for(int i = 0; i < rows; i++){
        for(int j = 0; j < cols; j++){
            if(displayAry[i][j] > 0 ){
                outFile1 << displayAry[i][j];
            } else {
                outFile1 << " ";
            }
        }
        outFile1 << endl;
    }
}

void PlotDisplayAry(Point* pointSet, int** displayAry, int numPts){
    // X is the row
    // Y is the col
    for(int i = 0 ; i < numPts; i++){
        displayAry
        [(int) pointSet[i].Xcoord]
        [(int) pointSet[i].Ycoord] = pointSet[i].Label;
    }
}

void loadPointSet(ifstream& inFile, Point* pointSet){
    int index = 0;
    int x,y;
    while(!inFile.eof()){
        inFile >> x;
        inFile >> y;

        pointSet[index].Xcoord = (double) x;
        pointSet[index].Ycoord = (double) y;
        pointSet[index].Label = 0;
        pointSet[index].Distance = 99999.0;

        index++;
    }
}
```

K =4


outFile1.txt — Edited
outFile1.txt — Edited
outFile1.txt — Edited
********** Result of iteration 1 **********
********** Result of iteration 2 **********
********** Result of iteration 3 **********
********** Result of iteration 4 **********
********** Result of iteration 5 **********
********** Result of iteration 6 **********
********** Result of iteration 7 **********
********** Result of iteration 8 **********
********** Result of iteration 9 **********
********** Result of iteration 10 **********
********** Result of iteration 11 **********
********** Result of iteration 12 **********

********** Result of iteration 13 **********

********** Result of iteration 14 **********



********** Result of iteration 15 **********

********** Result of iteration 16 **********

********** Result of iteration 17 **********

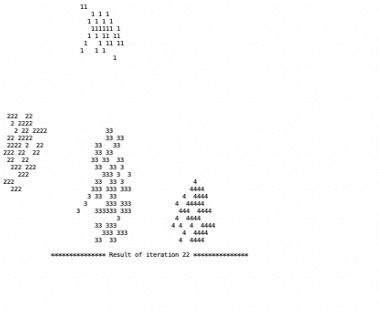
********** Result of iteration 18 **********

********** Result of iteration 19 **********

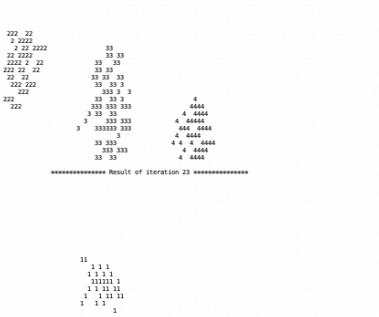
********** Result of iteration 20 **********

********** Result of iteration 21 **********

********** Result of iteration 21 **********



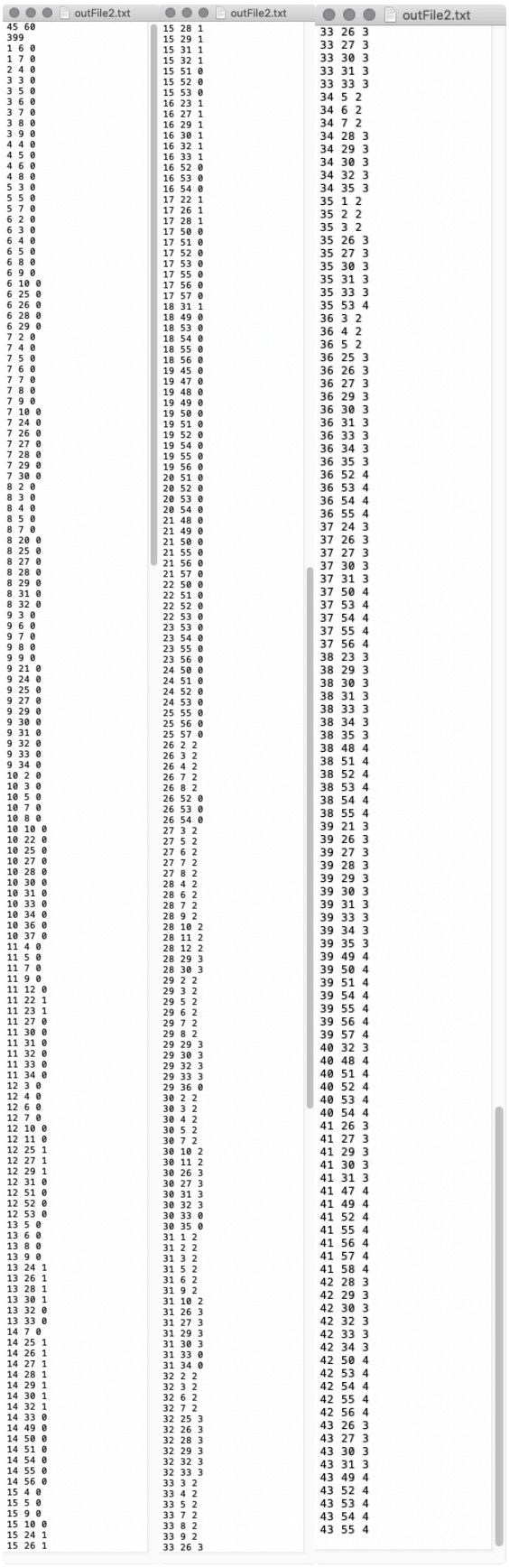
********** Result of iteration 22 **********



********** Result of iteration 23 **********

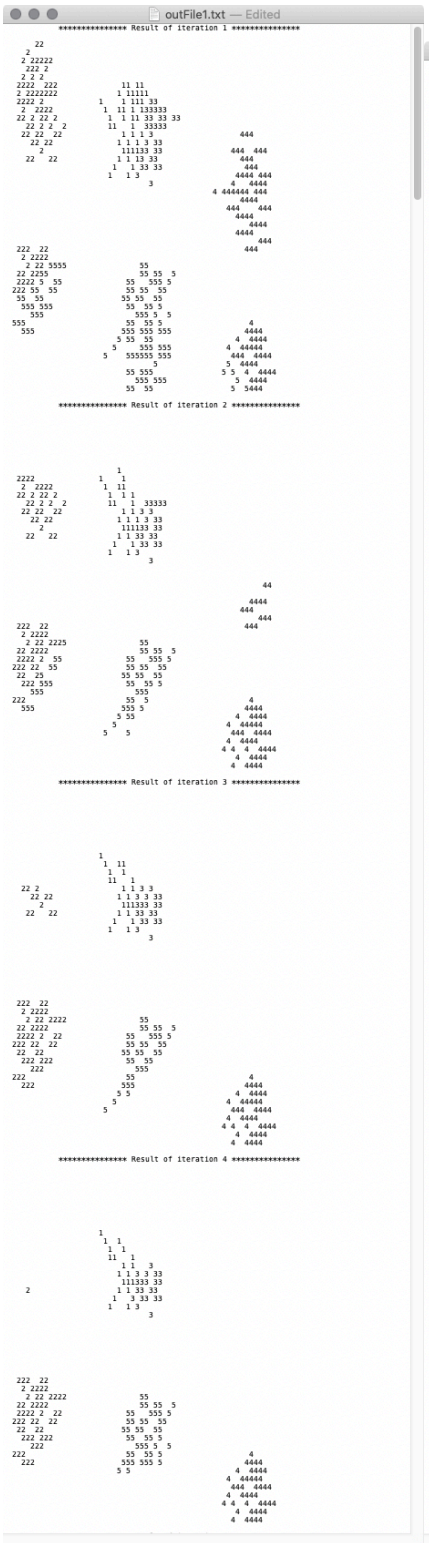
********** Result of iteration 24 **********

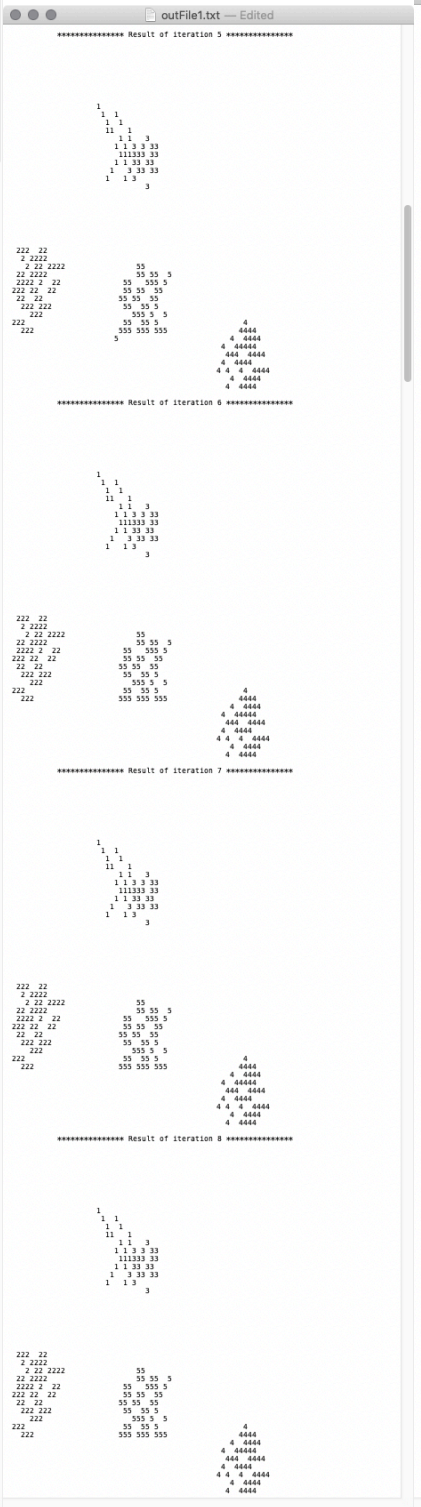
********** Result of iteration 25 **********

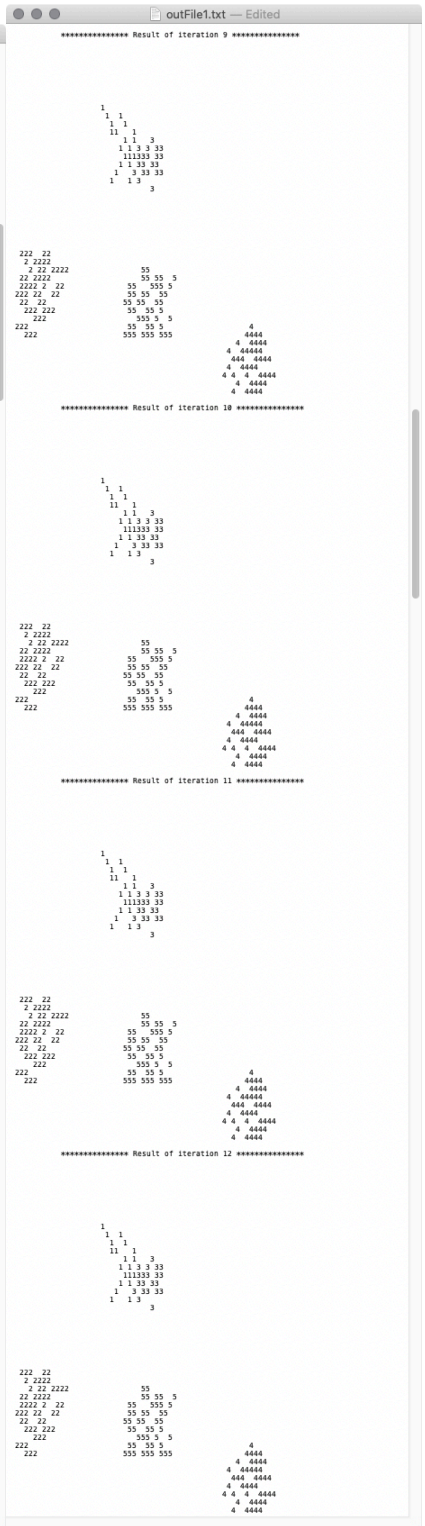

outFile2.txt
45 60
399
1 6 0
1 7 0
2 4 0
3 3 0
3 5 0
3 6 0
3 7 0
3 8 0
3 9 0
4 4 0
4 5 0
4 6 0
4 8 0
5 3 0
5 5 0
5 7 0
6 2 0
6 3 0
6 4 0
6 5 0
6 8 0
6 9 0
6 10 0
6 25 0
6 26 0
6 28 0
6 29 0
7 2 0
7 4 0
7 5 0
7 6 0
7 7 0
7 8 0
7 9 0
7 10 0
7 24 0
7 26 0
7 27 0
7 28 0
7 29 0
7 30 0
8 2 0
8 3 0
8 4 0
8 5 0
8 7 0
8 20 0
8 25 0
8 27 0
8 28 0
8 29 0
8 31 0
8 32 0
9 3 0
9 6 0
9 7 0
9 8 0
9 9 0
9 21 0
9 24 0
9 25 0
9 27 0
9 29 0
9 30 0
9 31 0
9 32 0
9 33 0
9 34 0
10 2 0
10 3 0
10 5 0
10 7 0
10 8 0
10 10 0
10 22 0
10 25 0
10 27 0
10 28 0
10 30 0
10 31 0
10 33 0
10 34 0
10 36 0
10 37 0
11 4 0
11 5 0
11 7 0
11 9 0
11 12 0
11 22 1
11 23 1
11 27 0
11 30 0
11 31 0
11 32 0
11 33 0
11 34 0
12 3 0
12 4 0
12 6 0
12 7 0
12 10 0
12 11 0
12 25 1
12 27 1
12 29 1
12 31 0
12 51 0
12 52 0
12 53 0
13 5 0
13 6 0
13 8 0
13 9 0
13 24 1
13 26 1
13 28 1
13 30 1
13 32 0
13 33 0
14 7 0
14 25 1
14 26 1
14 27 1
14 28 1
14 29 1
14 30 1
14 32 1
14 33 0
14 49 0
14 50 0
14 51 0
14 54 0
14 55 0
14 56 0
15 4 0
15 5 0
15 9 0
15 10 0
15 24 1
15 26 1
outFile2.txt
15 28 1
15 29 1
15 31 1
15 32 1
15 51 0
15 52 0
15 53 0
16 23 1
16 27 1
16 29 1
16 30 1
16 32 1
16 33 1
16 52 0
16 53 0
16 54 0
17 22 1
17 26 1
17 28 1
17 50 0
17 51 0
17 52 0
17 53 0
17 55 0
17 56 0
17 57 0
18 31 1
18 49 0
18 53 0
18 54 0
18 55 0
18 56 0
19 45 0
19 47 0
19 48 0
19 49 0
19 50 0
19 51 0
19 52 0
19 54 0
19 55 0
19 56 0
20 51 0
20 52 0
20 53 0
20 54 0
21 48 0
21 49 0
21 50 0
21 55 0
21 56 0
21 57 0
22 50 0
22 51 0
22 52 0
22 53 0
23 53 0
23 54 0
23 55 0
23 56 0
24 50 0
24 51 0
24 52 0
24 53 0
25 55 0
25 56 0
25 57 0
26 2 2
26 3 2
26 4 2
26 7 2
26 8 2
26 52 0
26 53 0
26 54 0
27 3 2
27 5 2
27 6 2
27 7 2
27 8 2
28 4 2
28 6 2
28 7 2
28 9 2
28 10 2
28 11 2
28 12 2
28 29 3
28 30 3
29 2 2
29 3 2
29 5 2
29 6 2
29 7 2
29 8 2
29 29 3
29 30 3
29 32 3
29 33 3
29 36 0
30 2 2
30 3 2
30 4 2
30 5 2
30 7 2
30 10 2
30 11 2
30 26 3
30 27 3
30 31 3
30 32 3
30 33 0
30 35 0
31 1 2
31 2 2
31 3 2
31 5 2
31 6 2
31 9 2
31 10 2
31 26 3
31 27 3
31 29 3
31 30 3
31 33 0
31 34 0
32 2 2
32 3 2
32 6 2
32 7 2
32 25 3
32 26 3
32 28 3
32 29 3
32 32 3
32 33 3
33 3 2
33 4 2
33 5 2
33 7 2
33 8 2
33 9 2
33 26 3
outFile2.txt
33 26 3
33 27 3
33 30 3
33 31 3
33 33 3
34 5 2
34 6 2
34 7 2
34 28 3
34 29 3
34 30 3
34 32 3
34 35 3
35 1 2
35 2 2
35 3 2
35 26 3
35 27 3
35 30 3
35 31 3
35 33 3
35 53 4
36 3 2
36 4 2
36 5 2
36 25 3
36 26 3
36 27 3
36 29 3
36 30 3
36 31 3
36 33 3
36 34 3
36 35 3
36 52 4
36 53 4
36 54 4
36 55 4
37 24 3
37 26 3
37 27 3
37 30 3
37 31 3
37 50 4
37 53 4
37 54 4
37 55 4
37 56 4
38 23 3
38 29 3
38 30 3
38 31 3
38 33 3
38 34 3
38 35 3
38 48 4
38 51 4
38 52 4
38 53 4
38 54 4
38 55 4
39 21 3
39 26 3
39 27 3
39 28 3
39 29 3
39 30 3
39 31 3
39 33 3
39 34 3
39 35 3
39 49 4
39 50 4
39 51 4
39 54 4
39 55 4
39 56 4
39 57 4
40 32 3
40 48 4
40 51 4
40 52 4
40 53 4
40 54 4
41 26 3
41 27 3
41 29 3
41 30 3
41 31 3
41 47 4
41 49 4
41 52 4
41 55 4
41 56 4
41 57 4
41 58 4
42 28 3
42 29 3
42 30 3
42 32 3
42 33 3
42 34 3
42 50 4
42 53 4
42 54 4
42 55 4
42 56 4
43 26 3
43 27 3
43 30 3
43 31 3
43 49 4
43 52 4
43 53 4
43 54 4
43 55 4

END OF K = 4

K = 5


outFile1.txt — Edited
********** Result of iteration 1 **********
********** Result of iteration 2 **********
********** Result of iteration 3 **********
********** Result of iteration 4 **********


outFile1.txt — Edited
********** Result of iteration 5 **********
********** Result of iteration 6 **********
********** Result of iteration 7 **********
********** Result of iteration 8 **********


outFile1.txt — Edited
********** Result of iteration 9 **********
********** Result of iteration 10 **********
********** Result of iteration 11 **********
********** Result of iteration 12 **********

outFile1.txt — Edited

********** Result of iteration 13 **********

********** Result of iteration 14 **********

********** Result of iteration 15 **********

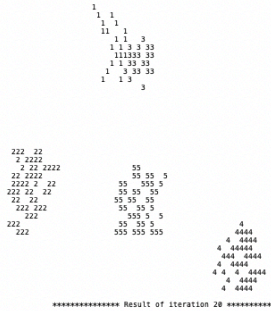
********** Result of iteration 16 **********

outFile1.txt — Edited

********** Result of iteration 17 **********

********** Result of iteration 18 **********

********** Result of iteration 19 **********



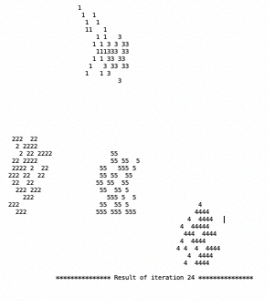
********** Result of iteration 20 **********

outFile1.txt — Edited

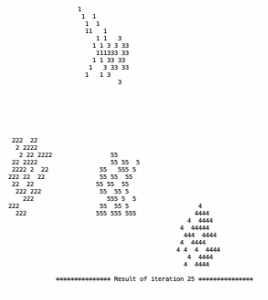
********** Result of iteration 21 **********

********** Result of iteration 22 **********

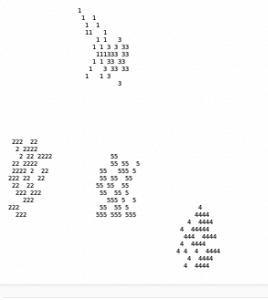
********** Result of iteration 23 **********



********** Result of iteration 24 **********



********** Result of iteration 25 **********



outFile2.txt

```
45 60
399
1 6 0
1 7 0
2 4 0
3 3 0
3 5 0
3 6 0
3 7 0
3 8 0
3 9 0
4 4 0
4 5 0
4 6 0
4 8 0
5 3 0
5 5 0
5 7 0
6 2 0
6 3 0
6 4 0
6 5 0
6 8 0
6 9 0
6 10 0
6 25 0
6 26 0
6 28 0
6 29 0
7 2 0
7 4 0
7 5 0
7 6 0
7 7 0
7 8 0
7 9 0
7 10 0
7 24 0
7 26 0
7 27 0
7 28 0
7 29 0
7 30 0
8 2 0
8 3 0
8 4 0
8 5 0
8 7 0
8 20 1
8 25 0
8 27 0
8 28 0
8 29 0
8 31 0
8 32 0
9 3 0
9 6 0
9 7 0
9 8 0
9 9 0
9 21 1
9 24 1
9 25 0
9 27 0
9 29 0
9 30 0
9 31 0
9 32 0
9 33 0
9 34 0
10 2 0
10 3 0
10 5 0
10 7 0
10 8 0
10 10 0
10 22 1
10 25 1
10 27 0
10 28 0
10 30 0
10 31 0
10 33 0
10 34 0
10 36 0
10 37 0
11 4 0
11 5 0
11 7 0
11 9 0
11 12 0
11 22 1
11 23 1
11 27 1
11 30 0
11 31 0
11 32 0
11 33 0
11 34 0
12 3 0
12 4 0
12 6 0
12 7 0
12 10 0
12 11 0
12 25 1
12 27 1
12 29 0
12 31 3
12 51 0
12 52 0
12 53 0
13 5 0
13 6 0
13 8 0
13 9 0
13 24 1
13 26 1
13 28 3
13 30 3
13 32 3
13 33 3
14 7 0
14 25 1
14 26 1
14 27 1
14 28 3
14 29 3
14 30 3
14 32 3
14 33 3
14 49 0
14 50 0
14 51 0
14 54 0
14 55 0
14 56 0
15 4 0
15 5 0
15 9 0
15 10 0
15 24 1
15 26 1
```

outFile2.txt

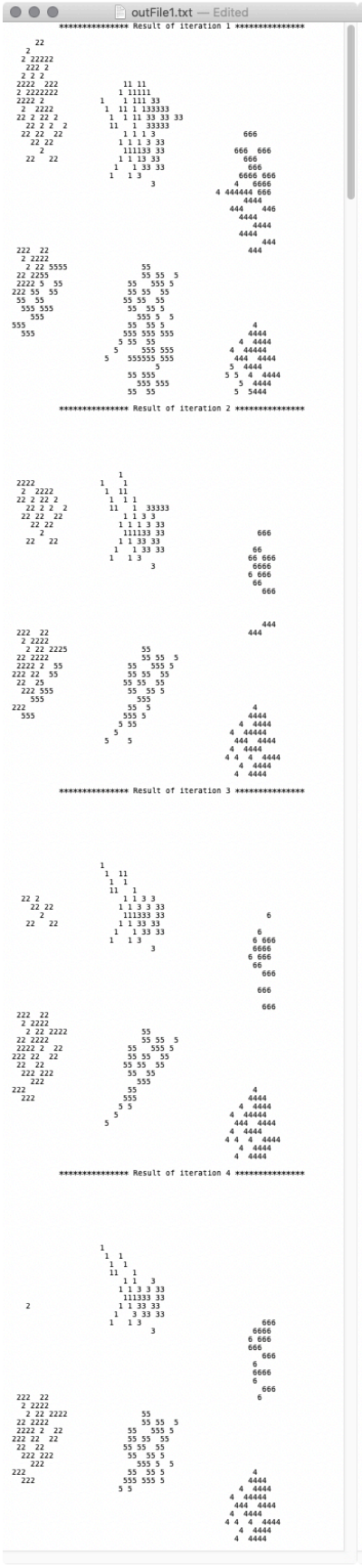
```
15 26 1
15 28 3
15 29 3
15 31 3
15 32 3
15 51 0
15 52 0
15 53 0
16 23 1
16 27 3
16 29 3
16 30 3
16 32 3
16 33 3
16 52 0
16 53 0
16 54 0
17 22 1
17 26 1
17 28 3
17 50 0
17 51 0
17 52 0
17 53 0
17 55 0
17 56 0
17 57 0
18 31 3
18 49 0
18 53 0
18 54 0
18 55 0
18 56 0
19 45 0
19 47 0
19 48 0
19 49 0
19 50 0
19 51 0
19 52 0
19 54 0
19 55 0
19 56 0
20 51 0
20 52 0
20 53 0
20 54 0
21 48 0
21 49 0
21 50 0
21 55 0
21 56 0
21 57 0
22 50 0
22 51 0
22 52 0
22 53 0
23 53 0
23 54 0
23 55 0
23 56 0
24 50 0
24 51 0
24 52 0
24 53 0
25 55 0
25 56 0
25 57 0
26 2 2
26 3 2
26 4 2
26 7 2
26 8 2
26 52 0
26 53 0
26 54 0
27 3 2
27 5 2
27 6 2
27 7 2
27 8 2
28 4 2
28 6 2
28 7 2
28 9 2
28 10 2
28 11 2
28 12 2
28 29 5
28 30 5
29 2 2
29 3 2
29 5 2
29 6 2
29 7 2
29 8 2
29 29 5
29 30 5
29 32 5
29 33 5
29 36 5
30 2 2
30 3 2
30 4 2
30 5 2
30 7 2
30 10 2
30 11 2
30 26 5
30 27 5
30 31 5
30 32 5
30 33 5
30 35 5
31 1 2
31 2 2
31 3 2
31 5 2
31 6 2
31 9 2
31 10 2
31 26 5
31 27 5
31 29 5
31 30 5
31 33 5
31 34 5
32 2 2
32 3 2
32 6 2
32 7 2
32 25 5
32 26 5
32 28 5
32 29 5
32 32 5
32 33 5
33 3 2
33 4 2
33 5 2
33 7 2
33 8 2
33 9 2
```

outFile2.txt

```
33 7 2
33 8 2
33 9 2
33 26 5
33 27 5
33 30 5
33 31 5
33 33 5
34 5 2
34 6 2
34 7 2
34 28 5
34 29 5
34 30 5
34 32 5
34 35 5
35 1 2
35 2 2
35 3 2
35 26 5
35 27 5
35 30 5
35 31 5
35 33 5
35 53 4
36 3 2
36 4 2
36 5 2
36 25 5
36 26 5
36 27 5
36 29 5
36 30 5
36 31 5
36 33 5
36 34 5
36 35 5
36 52 4
36 53 4
36 54 4
36 55 4
37 24 0
37 26 0
37 27 0
37 30 0
37 31 0
37 50 4
37 53 4
37 54 4
37 55 4
37 56 4
38 23 0
38 29 0
38 30 0
38 31 0
38 33 0
38 34 0
38 35 0
38 48 4
38 51 4
38 52 4
38 53 4
38 54 4
38 55 4
39 21 0
39 26 0
39 27 0
39 28 0
39 29 0
39 30 0
39 31 0
39 33 0
39 34 0
39 35 0
39 49 4
39 50 4
39 51 4
39 54 4
39 55 4
39 56 4
39 57 4
40 32 0
40 48 4
40 51 4
40 52 4
40 53 4
40 54 4
41 26 0
41 27 0
41 29 0
41 30 0
41 31 0
41 47 4
41 49 4
41 52 4
41 55 4
41 56 4
41 57 4
41 58 4
42 28 0
42 29 0
42 30 0
42 32 0
42 33 0
42 34 0
42 50 4
42 53 4
42 54 4
42 55 4
42 56 4
43 26 0
43 27 0
43 30 0
43 31 0
43 49 4
43 52 4
43 53 4
43 54 4
43 55 4
```

End of K = 5

K = 6


outFile1.txt — Edited
********** Result of iteration 1 **********
********** Result of iteration 2 **********
********** Result of iteration 3 **********
********** Result of iteration 4 **********

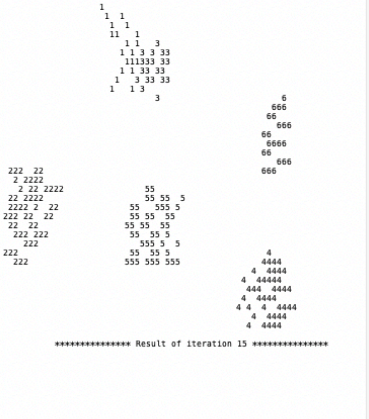

outFile1.txt — Edited
********** Result of iteration 5 **********
********** Result of iteration 6 **********
********** Result of iteration 7 **********
********** Result of iteration 8 **********


outFile1.txt — Edited
********** Result of iteration 9 **********
********** Result of iteration 10 **********
********** Result of iteration 11 **********
********** Result of iteration 12 **********
********** Result of iteration 13 **********

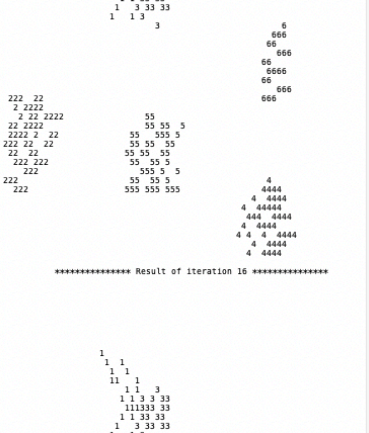
outFile1.txt — Edited

********** Result of iteration 13 **********

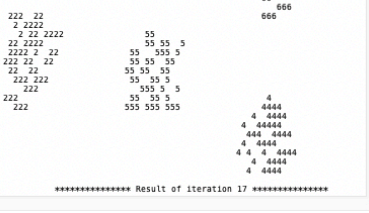
********** Result of iteration 14 **********



********** Result of iteration 15 **********



********** Result of iteration 16 **********

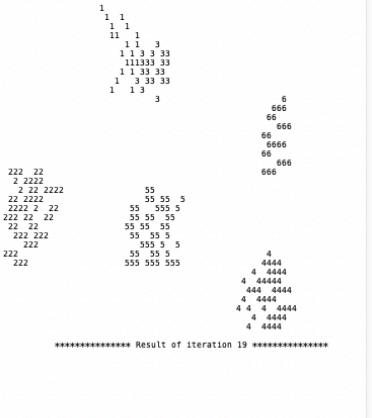


********** Result of iteration 17 **********

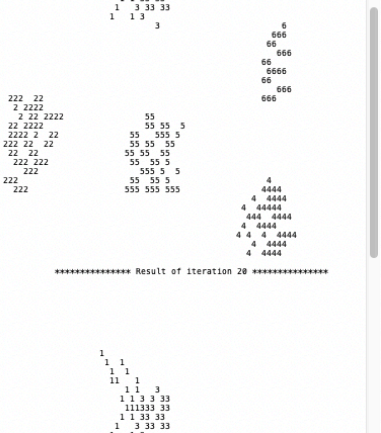
outFile1.txt — Edited

********** Result of iteration 17 **********

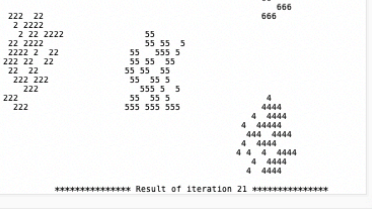
********** Result of iteration 18 **********



********** Result of iteration 19 **********



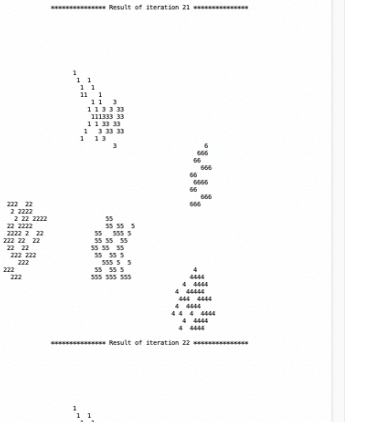
********** Result of iteration 20 **********



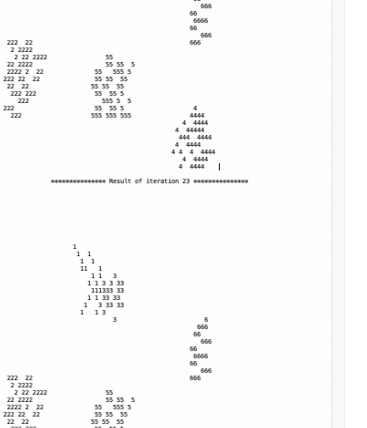
********** Result of iteration 21 **********

outFile1.txt — Edited

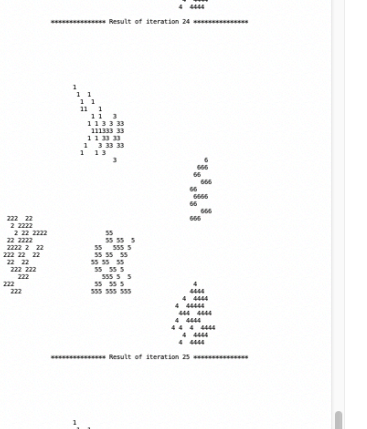
********** Result of iteration 21 **********



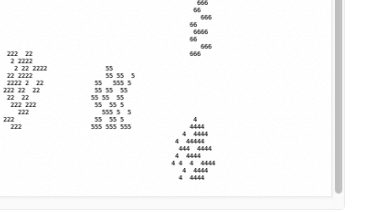
********** Result of iteration 22 **********



********** Result of iteration 23 **********



********** Result of iteration 24 **********



********** Result of iteration 25 **********

outFile2.txt

```
45 60
399
1 6 0
1 7 0
2 4 0
3 3 0
3 5 0
3 6 0
3 7 0
3 8 0
3 9 0
4 4 0
4 5 0
4 6 0
4 8 0
5 3 0
5 5 0
5 7 0
6 2 0
6 3 0
6 4 0
6 5 0
6 8 0
6 9 0
6 10 0
6 25 0
6 26 0
6 28 0
6 29 0
7 2 0
7 4 0
7 5 0
7 6 0
7 7 0
7 8 0
7 9 0
7 10 0
7 24 0
7 26 0
7 27 0
7 28 0
7 29 0
7 30 0
8 2 0
8 3 0
8 4 0
8 5 0
8 7 0
8 20 1
8 25 0
8 27 0
8 28 0
8 29 0
8 31 0
8 32 0
9 3 0
9 6 0
9 7 0
9 8 0
9 9 0
9 21 1
9 24 1
9 25 0
9 27 0
9 29 0
9 30 0
9 31 0
9 32 0
9 33 0
9 34 0
10 2 0
10 3 0
10 5 0
10 7 0
10 8 0
10 10 0
10 22 1
10 25 1
10 27 0
10 28 0
10 30 0
10 31 0
10 33 0
10 34 0
10 36 0
10 37 0
11 4 0
11 5 0
11 7 0
11 9 0
11 12 0
11 22 1
11 23 1
11 27 1
11 30 0
11 31 0
11 32 0
11 33 0
11 34 0
12 3 0
12 4 0
12 6 0
12 7 0
12 10 0
12 11 0
12 25 1
12 27 1
12 29 0
12 31 3
12 51 0
12 52 0
12 53 0
13 5 0
13 6 0
13 8 0
13 9 0
13 24 1
13 26 1
13 28 3
13 30 3
13 32 3
13 33 3
14 7 0
14 25 1
14 26 1
14 27 1
14 28 3
14 29 3
14 30 3
14 32 3
14 33 3
14 49 0
14 50 0
14 51 0
14 54 0
14 55 0
14 56 0
15 4 0
15 5 0
15 9 0
15 10 0
15 24 1
15 26 1
```

outFile2.txt

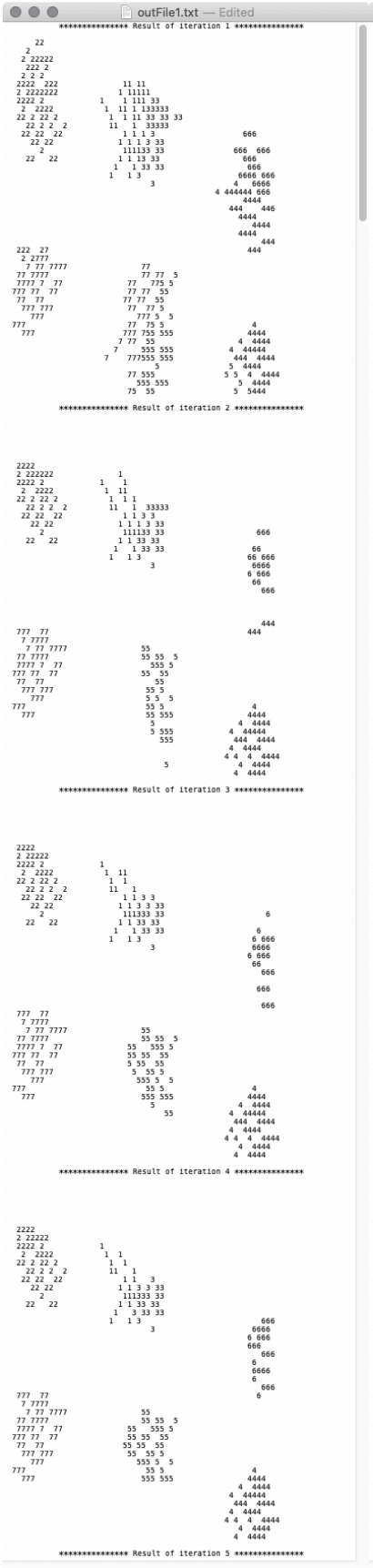
```
15 5 0
15 9 0
15 10 0
15 24 1
15 26 1
15 28 3
15 29 3
15 31 3
15 32 3
15 51 0
15 52 0
15 53 0
16 23 1
16 27 3
16 29 3
16 30 3
16 32 3
16 33 3
16 52 0
16 53 0
16 54 0
17 22 1
17 26 1
17 28 3
17 50 0
17 51 0
17 52 0
17 53 0
17 55 0
17 56 0
17 57 0
18 31 3
18 49 0
18 53 0
18 54 0
18 55 0
18 56 6
19 45 0
19 47 0
19 48 0
19 49 0
19 50 0
19 51 0
19 52 0
19 54 6
19 55 6
19 56 6
20 51 0
20 52 0
20 53 6
20 54 6
21 48 0
21 49 0
21 50 0
21 55 6
21 56 6
21 57 6
22 50 0
22 51 0
22 52 6
22 53 6
23 53 6
23 54 6
23 55 6
23 56 6
24 50 0
24 51 0
24 52 6
24 53 6
25 55 6
25 56 6
25 57 6
26 2 2
26 3 2
26 4 2
26 7 2
26 8 2
26 52 6
26 53 6
26 54 6
27 3 2
27 5 2
27 6 2
27 7 2
27 8 2
28 4 2
28 6 2
28 7 2
28 9 2
28 10 2
28 11 2
28 12 2
28 29 5
28 30 5
29 2 2
29 3 2
29 5 2
29 6 2
29 7 2
29 8 2
29 29 5
29 30 5
29 32 5
29 33 5
29 36 5
30 2 2
30 3 2
30 4 2
30 5 2
30 7 2
30 10 2
30 11 2
30 26 5
30 27 5
30 31 5
30 32 5
30 33 5
30 35 5
31 1 2
31 2 2
31 3 2
31 5 2
31 6 2
31 9 2
31 10 2
31 26 5
31 27 5
31 29 5
31 30 5
31 33 5
31 34 5
32 2 2
32 3 2
32 6 2
32 7 2
32 25 5
32 26 5
32 28 5
32 29 5
32 32 5
32 33 5
33 3 2
33 4 2
```

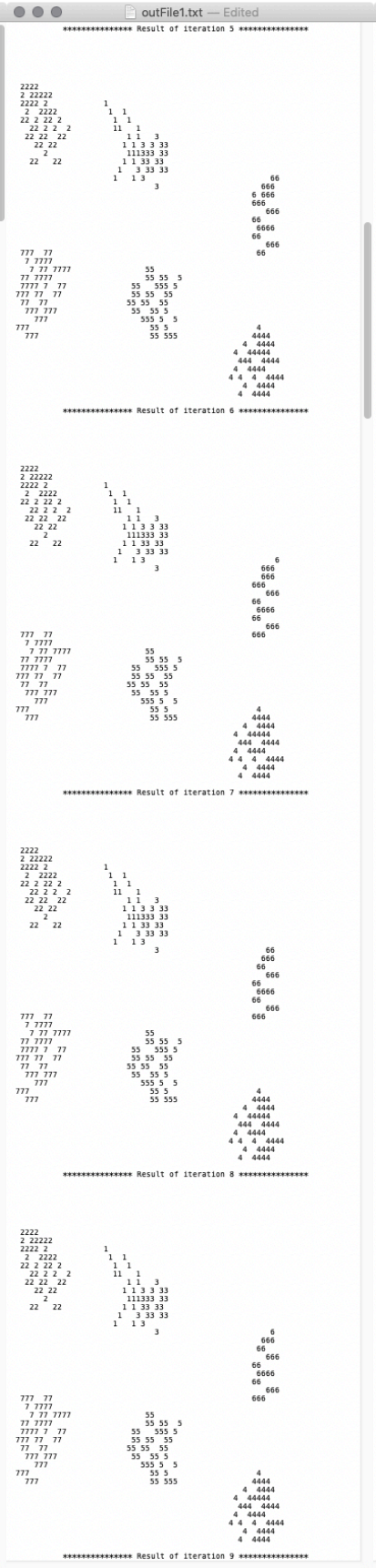
outFile2.txt

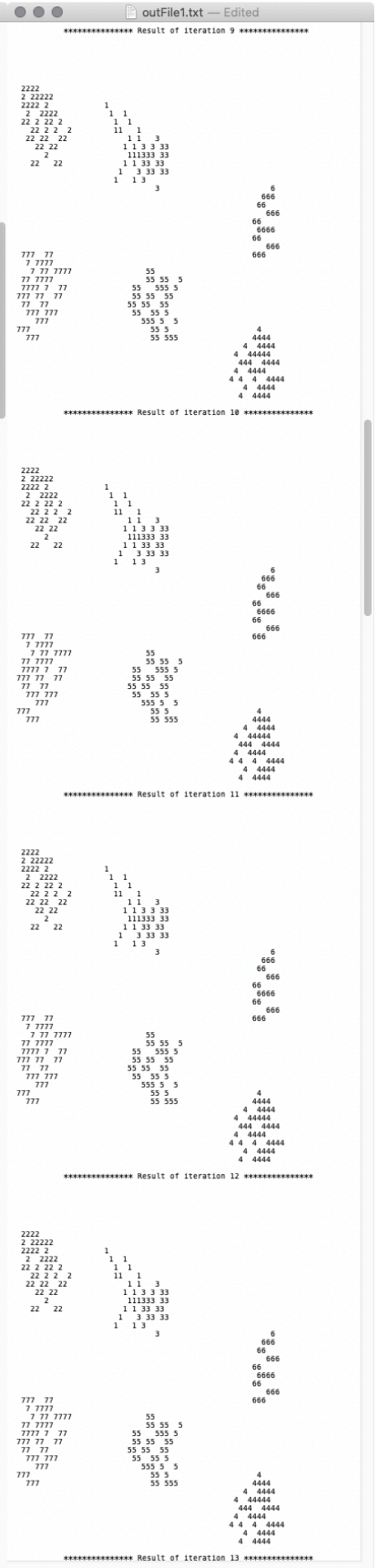
```
31 5 2
31 6 2
31 9 2
31 10 2
31 26 5
31 27 5
31 29 5
31 30 5
31 33 5
31 34 5
32 2 2
32 3 2
32 6 2
32 7 2
32 25 5
32 26 5
32 28 5
32 29 5
32 32 5
32 33 5
33 3 2
33 4 2
33 5 2
33 7 2
33 8 2
33 9 2
33 26 5
33 27 5
33 30 5
33 31 5
33 33 5
34 5 2
34 6 2
34 7 2
34 28 5
34 29 5
34 30 5
34 32 5
34 35 5
35 1 2
35 2 2
35 3 2
35 26 5
35 27 5
35 30 5
35 31 5
35 33 5
35 53 4
36 3 2
36 4 2
36 5 2
36 25 5
36 26 5
36 27 5
36 29 5
36 30 5
36 31 5
36 33 5
36 34 5
36 35 5
36 52 4
36 53 4
36 54 4
36 55 4
37 24 0
37 26 0
37 27 0
37 30 0
37 31 0
37 50 4
37 53 4
37 54 4
37 55 4
37 56 4
38 23 0
38 29 0
38 30 0
38 31 0
38 33 0
38 34 0
38 35 0
38 48 4
38 51 4
38 52 4
38 53 4
38 54 4
38 55 4
39 21 0
39 26 0
39 27 0
39 28 0
39 29 0
39 30 0
39 31 0
39 33 0
39 34 0
39 35 0
39 49 4
39 50 4
39 51 4
39 54 4
39 55 4
39 56 4
39 57 4
40 32 0
40 48 4
40 51 4
40 52 4
40 53 4
40 54 4
41 26 0
41 27 0
41 29 0
41 30 0
41 31 0
41 47 4
41 49 4
41 52 4
41 55 4
41 56 4
41 57 4
41 58 4
42 28 0
42 29 0
42 30 0
42 32 0
42 33 0
42 34 0
42 50 4
42 53 4
42 54 4
42 55 4
42 56 4
43 26 0
43 27 0
43 30 0
43 31 0
43 49 4
43 52 4
43 53 4
43 54 4
43 55 4
```

END OF K = 6

K = 7

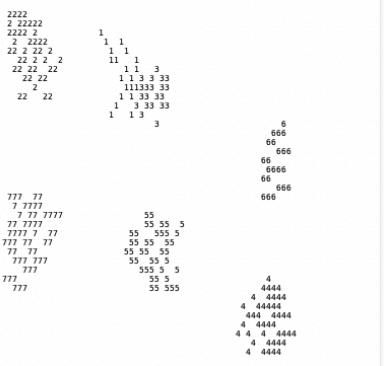

outFile1.txt — Edited
********** Result of iteration 1 **********
********** Result of iteration 2 **********
********** Result of iteration 3 **********
********** Result of iteration 4 **********
********** Result of iteration 5 **********


outFile1.txt — Edited
********** Result of iteration 5 **********
********** Result of iteration 6 **********
********** Result of iteration 7 **********
********** Result of iteration 8 **********
********** Result of iteration 9 **********

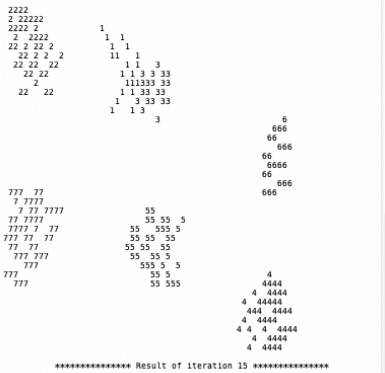

outFile1.txt — Edited
********** Result of iteration 9 **********
********** Result of iteration 10 **********
********** Result of iteration 11 **********
********** Result of iteration 12 **********
********** Result of iteration 13 **********

outFile1.txt — Edited

```
********** Result of iteration 13 **********
```



```
********** Result of iteration 14 **********
```



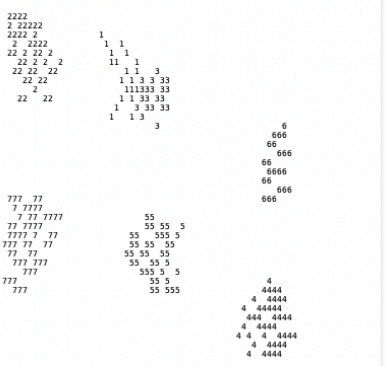
```
********** Result of iteration 15 **********
```

```
********** Result of iteration 16 **********
```

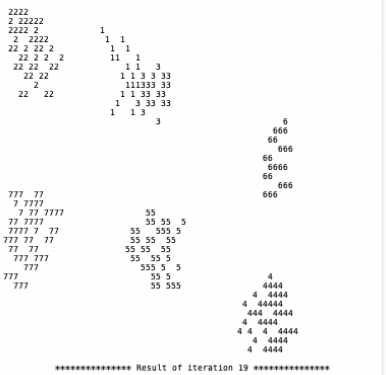
```
********** Result of iteration 17 **********
```

outFile1.txt — Edited

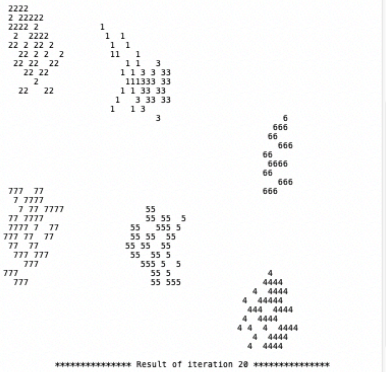
```
********** Result of iteration 17 **********
```



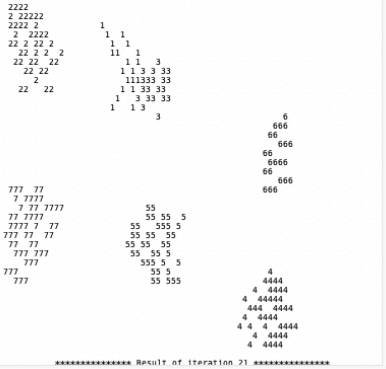
```
********** Result of iteration 18 **********
```



```
********** Result of iteration 19 **********
```



```
********** Result of iteration 20 **********
```



```
********** Result of iteration 21 **********
```

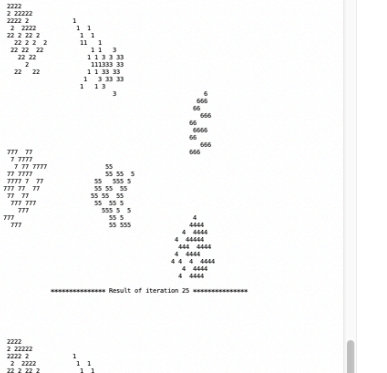
outFile1.txt — Edited

```
                                                4  4444
********** Result of iteration 21 **********
```

```
********** Result of iteration 22 **********
```

```
********** Result of iteration 23 **********
```

```
********** Result of iteration 24 **********
```



```
********** Result of iteration 25 **********
```

outFile2.txt

```
45 60
399
1 6 0
1 7 0
2 4 0
3 3 0
3 5 0
3 6 0
3 7 0
3 8 0
3 9 0
4 4 0
4 5 0
4 6 0
4 8 0
5 3 0
5 5 0
5 7 0
6 2 2
6 3 2
6 4 2
6 5 2
6 8 0
6 9 0
6 10 0
6 25 0
6 26 0
6 28 0
6 29 0
7 2 2
7 4 2
7 5 2
7 6 2
7 7 2
7 8 2
7 9 0
7 10 0
7 24 0
7 26 0
7 27 0
7 28 0
7 29 0
7 30 0
8 2 2
8 3 2
8 4 2
8 5 2
8 7 2
8 20 1
8 25 0
8 27 0
8 28 0
8 29 0
8 31 0
8 32 0
9 3 2
9 6 2
9 7 2
9 8 2
9 9 2
9 21 1
9 24 1
9 25 0
9 27 0
9 29 0
9 30 0
9 31 0
9 32 0
9 33 0
9 34 0
10 2 2
10 3 2
10 5 2
10 7 2
10 8 2
10 10 2
10 22 1
10 25 1
10 27 0
10 28 0
10 30 0
10 31 0
10 33 0
10 34 0
10 36 0
10 37 0
11 4 2
11 5 2
11 7 2
11 9 2
11 12 2
11 22 1
11 23 1
11 27 1
11 30 0
11 31 0
11 32 0
11 33 0
11 34 0
12 3 2
12 4 2
12 6 2
12 7 2
12 10 2
12 11 2
12 25 1
12 27 1
12 29 0
12 31 3
12 51 0
12 52 0
12 53 0
13 5 2
13 6 2
13 8 2
13 9 2
13 24 1
13 26 1
13 28 3
13 30 3
13 32 3
13 33 3
14 7 2
14 25 1
14 26 1
14 27 1
14 28 3
14 29 3
14 30 3
14 32 3
14 33 3
14 49 0
14 50 0
14 51 0
14 54 0
14 55 0
14 56 0
15 4 2
15 5 2
15 9 2
15 10 2
15 24 1
15 26 1
```

outFile2.txt

```
15 26 1
15 28 3
15 29 3
15 31 3
15 32 3
15 51 0
15 52 0
15 53 0
16 23 1
16 27 3
16 29 3
16 30 3
16 32 3
16 33 3
16 52 0
16 53 0
16 54 0
17 22 1
17 26 1
17 28 3
17 50 0
17 51 0
17 52 0
17 53 0
17 55 0
17 56 0
17 57 0
18 31 3
18 49 0
18 53 0
18 54 0
18 55 0
18 56 6
19 45 0
19 47 0
19 48 0
19 49 0
19 50 0
19 51 0
19 52 0
19 54 6
19 55 6
19 56 6
20 51 0
20 52 0
20 53 6
20 54 6
21 48 0
21 49 0
21 50 0
21 55 6
21 56 6
21 57 6
22 50 0
22 51 0
22 52 6
22 53 6
23 53 6
23 54 6
23 55 6
23 56 6
24 50 0
24 51 0
24 52 6
24 53 6
25 55 6
25 56 6
25 57 6
26 2 7
26 3 7
26 4 7
26 7 7
26 8 7
26 52 6
26 53 6
26 54 6
27 3 7
27 5 7
27 6 7
27 7 7
27 8 7
28 4 7
28 6 7
28 7 7
28 9 7
28 10 7
28 11 7
28 12 7
28 29 5
28 30 5
29 2 7
29 3 7
29 5 7
29 6 7
29 7 7
29 8 7
29 29 5
29 30 5
29 32 5
29 33 5
29 36 5
30 2 7
30 3 7
30 4 7
30 5 7
30 7 7
30 10 7
30 11 7
30 26 5
30 27 5
30 31 5
30 32 5
30 33 5
30 35 5
31 1 7
31 2 7
31 3 7
31 5 7
31 6 7
31 9 7
31 10 7
31 26 5
31 27 5
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32 3 7
32 6 7
32 7 7
32 25 5
32 26 5
32 28 5
32 29 5
32 32 5
32 33 5
33 3 7
33 4 7
33 5 7
33 7 7
33 8 7
33 9 7
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outFile2.txt

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33 8 7
33 9 7
33 26 5
33 27 5
33 30 5
33 31 5
33 33 5
34 5 7
34 6 7
34 7 7
34 28 5
34 29 5
34 30 5
34 32 5
34 35 5
35 1 7
35 2 7
35 3 7
35 26 0
35 27 0
35 30 5
35 31 5
35 33 5
35 53 4
36 3 7
36 4 7
36 5 7
36 25 0
36 26 0
36 27 0
36 29 0
36 30 5
36 31 5
36 33 5
36 34 5
36 35 5
36 52 4
36 53 4
36 54 4
36 55 4
37 24 0
37 26 0
37 27 0
37 30 0
37 31 0
37 50 4
37 53 4
37 54 4
37 55 4
37 56 4
38 23 0
38 29 0
38 30 0
38 31 0
38 33 0
38 34 0
38 35 0
38 48 4
38 51 4
38 52 4
38 53 4
38 54 4
38 55 4
39 21 0
39 26 0
39 27 0
39 28 0
39 29 0
39 30 0
39 31 0
39 33 0
39 34 0
39 35 0
39 49 4
39 50 4
39 51 4
39 54 4
39 55 4
39 56 4
39 57 4
40 32 0
40 48 4
40 51 4
40 52 4
40 53 4
40 54 4
41 26 0
41 27 0
41 29 0
41 30 0
41 31 0
41 47 4
41 49 4
41 52 4
41 55 4
41 56 4
41 57 4
41 58 4
42 28 0
42 29 0
42 30 0
42 32 0
42 33 0
42 34 0
42 50 4
42 53 4
42 54 4
42 55 4
42 56 4
43 26 0
43 27 0
43 30 0
43 31 0
43 49 4
43 52 4
43 53 4
43 54 4
43 55 4
```

END OF K = 7