

```

#include <iostream>
#include <cmath>
#include <map>
#include <cstdlib>
#include <deque>
#include <vector>

using namespace std;

deque<int> new_life;
deque<int> old_life;
deque<int> living;
deque<int> living_candidats;
deque<int> killing_candidats;
vector<int> life_pop;
vector<int> life_exp;
int life_pop_max;
int roww, coll;
int **MM;
int *rr;
int print_counter = 1;

void print_matrix(int **M, int row, int col)
{
    for(int i=0;i<row;i++)
    {
        for(int u=0;u<col;u++)
        {
            if(M[i][u]==1)
            {
                cout<<"o"<<" ";
            }
            else
            {
                cout<<"_"<<" ";
            }
        }
        cout<<endl;
    }
    cout<<endl;
}

void print_ar(int *ar, int n)
{
    for(int i=0;i<n;i++)
    {
        cout<<ar[i]<<" ";
    }
    cout<<endl;
}

void print_ar_norm(int ar[], int n)
{
    for(int i=0;i<n;i++)
    {
        cout<<ar[i]<<" ";
    }
    cout<<endl;
}

void print_vec(vector<int> vec)
{

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    for(int i=0;i<vec.size();i++)
    {
        cout<<vec[i]<<" ";
    }
    cout<<endl;
}
void print_deq(deque<int> &mydeq)
{
    for(int i=0;i<mydeq.size();i++)
    {
        cout<<mydeq[i]<<" ";
    }
    //cout<<mydeq.size();
    //cout<<"mydeq";
    cout<<endl;
}
void print_deq2(deque<int> &mydeq)
{
    for(int i=0;i<mydeq.size();i+=2)
    {
        cout<<mydeq[i]<<" ";
        cout<<mydeq[i+1]<<" ";
    }
    //cout<<mydeq.size();
    //cout<<"mydeq";
    cout<<endl;
}
void print_deq_living(deque<int> &mydeq)
{
    for(int i=0;i<mydeq.size();i+=2)
    {
        cout<<mydeq[i]<<" "<<mydeq[i+1]<<" ";
    }
    //cout<<mydeq.size();
    //cout<<"mydeq";
    cout<<endl;
}
int count_life_kolvo(int* ar, int length)
{
    int kolvo=0;
    for(int i=0;i<length;i++)
    {
        if(ar[i]==1)
        {
            kolvo++;
        }
    }
    return kolvo;
}
void coord_recalc(int direc, int sign)
{
    //direc 1 -> W
    //direc -1 -> N

    //sign > 0 -> exp
    //sign <= 0 -> retraction

    if(direc==1)
    {

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for(int i=0;i<living.size();i+=2)
{
    if(sign>0)
    {
        living[i+1]+=sign;
    }
    else
    {
        living[i+1]+=sign;
    }
}
}
else
{
    for(int i=0;i<living.size();i+=2)
    {
        if(sign==1)
        {
            living[i]+=sign;
        }
        else
        {
            living[i]+=sign;
        }
    }
}

/*int t;
if(direc==1)
{
    for(int i=0;i<row;i++)
    {
        if(sign==1)
        {
            for(int u=col-1;u>0;u--)
            {
                if(M[i][u]==1)
                {
                    t=M[i][u];
                    M[i][u]=M[i][u+1];
                    M[i][u+1]=t;
                }
            }
        }
        else
        {
            for(int u=0;u<col;u++)
            {
                if(M[i][u]==1)
                {
                    t=M[i][u];
                    M[i][u]=M[i][u-1];
                    M[i][u-1]=t;
                }
            }
        }
    }
}
else
{

```

```

for(int i=0;i<row;i++)
{
    for(int u=col;u>0;u--)
    {
        if(M[i][u]==1)
        {
            if(sign==1)
            {
            }
        }
    }
}
}*/
}
void coord_recalc_candidates(int direc, int sign)
{
    if(direc==1)
    {
        for(int i=0;i<living_candidats.size();i+=2)
        {
            if(sign>0)
            {
                living_candidats[i+1]+=sign;
            }
            else
            {
                living_candidats[i+1]+=sign;
            }
        }

        for(int i=0;i<killing_candidats.size();i+=2)
        {
            if(sign>0)
            {
                killing_candidats[i+1]+=sign;
            }
            else
            {
                killing_candidats[i+1]+=sign;
            }
        }
    }
    else
    {
        for(int i=0;i<living_candidats.size();i+=2)
        {
            if(sign>0)
            {
                living_candidats[i]+=sign;
            }
            else
            {
                living_candidats[i]+=sign;
            }
        }

        for(int i=0;i<killing_candidats.size();i+=2)
        {
            if(sign>0)

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```

        {
            killing_candidats[i]+=sign;
        }
        else
        {
            killing_candidats[i]+=sign;
        }
    }
}
}

```

```

int** expansion_S(int **M,int **r, int &row, int &col, int step, int exp_red, int fill_val)

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```

{
    //print_matrix(M,row,col);
    if(exp_red>0)
    {
        M=(int**)realloc(M,(row+step)*sizeof(int*));
        //cout<<"test5.0"<<endl;
        //cout<<"*r="<<*r<<endl;
        //cout<<"row="<<row<<" col="<<col<<" step="<<step<<endl;
        (*r)=(int**)realloc((*r),(row*col+col*step)*sizeof(int));
        //cout<<" *r1="<<*r<<endl;
        //cout<<"test5.1"<<endl;
        for(int i=0;i<row+step;i++)
        {
            M[i]=(*r)+i*col;
        }
        //cout<<"test5.2"<<endl;

        for(int i=row;i<row+step;i++)
        {
            for(int u=0;u<col;u++)
            {
                M[i][u]=fill_val;
            }
        }
        //cout<<"test5.3"<<endl;
        row=row+step;
    }
    else if(exp_red<0 && row-step>=0)
    {
        M=(int**)realloc(M,(row-step)*sizeof(int*));
        (*r)=(int**)realloc((*r),(row*col-col*step)*sizeof(int));

        for(int i=0;i<row-step;i++)
        {
            M[i]=(*r)+i*col;
        }
        row=row-step;
    }
    //print_matrix(M,row,col);
    return M;
}

```

```

/*void expansion_SS(int step, int exp_red, int fill_val)

```

```

{
    //print_matrix(MM,roww,coll);
    if(exp_red>0)
    {
        MM=(int**)realloc(MM,(roww+step)*sizeof(int*));
    }
}

```

```

//cout<<"test5.0"<<endl;
//cout<<"row="<<roww<<" col="<<coll<<" step="<<step<<endl;
rr=(int*)realloc(rr,(roww*coll+coll*step)*sizeof(int));
//cout<<"test5.1"<<endl;
for(int i=0;i<roww+step;i++)
{
    MM[i]=rr+i*coll;
}
//cout<<"test5.2"<<endl;

for(int i=roww;i<roww+step;i++)
{
    for(int u=0;u<coll;u++)
    {
        MM[i][u]=fill_val;
    }
}
//cout<<"test5.3"<<endl;
roww=roww+step;
}
else if(exp_red<0 && roww-step>=0)
{
    MM=(int**)realloc(MM,(roww-step)*sizeof(int*));
    rr=(int*)realloc(rr,(roww*coll-coll*step)*sizeof(int));

    for(int i=0;i<roww-step;i++)
    {
        MM[i]=rr+i*coll;
    }
    roww=roww-step;
}
//print_matrix(MM,roww,coll);
}*/

int** expansion_N(int **M,int **r, int &row, int &col, int step, int exp_red, int fill_val)
{
    int t;
    if(exp_red>0)
    {
        M=(int**)realloc(M,(row+step)*sizeof(int*));
        (*r)=(int*)realloc((*r),(row*col+col*step)*sizeof(int));

        for(int i=0;i<row+step;i++)
        {
            M[i]=(*r)+i*col;
        }

        for(int i=row;i<row+step;i++)
        {
            for(int u=0;u<col;u++)
            {
                M[i][u]=fill_val;
            }
        }
        for(int i=(row+step)*col-coll*step;i<(row+step)*col;i++)
        {
            for(int u=i;u>0;u--)
            {
                t=(*r)[u];
                (*r)[u]=(*r)[u-1];
            }
        }
    }
}

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```

        (*r)[u-1]=t;
    }
}
row=row+step;
}
else if(exp_red<0 && row-step>=0)
{
    for(int i=col*step;i>0;i--)
    {
        for(int u=i;u<col*row-1;u++)
        {
            t=(*r)[u];
            (*r)[u]=(*r)[u+1];
            (*r)[u+1]=t;
        }
    }

    M=(int**)realloc(M,(row-step)*sizeof(int*));
    (*r)=(int*)realloc((*r),(row*col-col*step)*sizeof(int));

    for(int i=0;i<row-step;i++)
    {
        M[i]=(*r)+i*col;
    }
    row=row-step;
}
//print_matrix(M,row,col);
return M;
}

int** expansion_E(int **M,int **r, int &row, int &col, int step, int exp_red, int fill_val)
{
    int t;
    if(exp_red>0)
    {
        (*r)=(int*)realloc((*r),((col+step)*row)*sizeof(int));

        for(int i=0;i<row;i++)
        {
            M[i]=(*r)+i*(col+step);
        }
        for(int i=col*row;i<(col+step)*row;i++)
        {
            (*r)[i]=fill_val;
        }
        for(int i=0;i<row;i++)
        {
            for(int u=0;u<step;u++)
            {
                for(int j=col*row+u+i*step;j>(col+step)*(i+1)-step+u;j--)
                {
                    t=(*r)[j];
                    (*r)[j]=(*r)[j-1];
                    (*r)[j-1]=t;
                }
            }
        }
        col=col+step;
    }
    else if(exp_red<0 && col-step>=0)

```

```

{
    for(int i=row-1;i>0;i--)
    {
        for(int u=0;u<step;u++)
        {
            for(int j=i*col-1-u;j<row*col-1;j++)
            {
                t=(*r)[j];
                (*r)[j]=(*r)[j+1];
                (*r)[j+1]=t;
            }
            //print_matrix(M, row, col);
        }
    }
    (*r)=(int*)realloc((*r),((col-step)*row)*sizeof(int));
    for(int i=0;i<row;i++)
    {
        M[i]=(*r)+i*(col-step);
    }
    col=col-step;
}
return M;
}

int** expansion_W(int **M,int **r, int &row, int &col, int step, int exp_red, int fill_val)
{
    int t;
    if(exp_red>0)
    {
        (*r)=(int*)realloc((*r),((col+step)*row)*sizeof(int));

        for(int i=0;i<row;i++)
        {
            M[i]=(*r)+i*(col+step);
        }
        for(int i=col*row;i<(col+step)*row;i++)
        {
            (*r)[i]=fill_val;
        }
        for(int i=0;i<row;i++)
        {
            for(int u=0;u<step;u++)
            {
                for(int j=col*row+u+i*step;j>(col+step)*(i)+u;j--)
                {
                    t=(*r)[j];
                    (*r)[j]=(*r)[j-1];
                    (*r)[j-1]=t;
                }
            }
        }
        col=col+step;
    }
    else if(exp_red<0 && col-step>=0)
    {
        for(int i=row;i>0;i--)
        {
            for(int u=0;u<step;u++)
            {
                for(int j=i*col-col+u;j<row*col-1;j++)

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```

    {
        t=(*r)[j];
        (*r)[j]=(*r)[j+1];
        (*r)[j+1]=t;
    }
    //print_matrix(M, row, col);
}
}
(*r)=(int*)realloc(*r,((col-step)*row)*sizeof(int));
for(int i=0;i<row;i++)
{
    M[i]=(*r)+i*(col-step);
}
col=col-step;
}
return M;
}

```

```

void fill_matrix(int** M, int row, int col, int* ar)
{
    int j=0,flag;
    int first,second;
    for(int i=0;i<row;i++)
    {
        M[i][0]=0;
        M[0][i]=0;
        M[i][row-1]=0;
        M[row-1][i]=0;
    }
    for(int i=1;i<row-1;i++)
    {
        for(int u=1;u<col-1;u++)
        {
            M[i][u]=ar[j];
            if(ar[j]==1)
            {
                //living.push_back(i);
                //living.push_back(u);
                for(int x=i-1;x<=i+1;x++)
                {
                    for(int y=u-1;y<=u+1;y++)
                    {
                        // need to push_back unique x and y
                        flag=0;
                        //cout<<"x="<<x<<" y="<<y<<endl;
                        for(int k=0;k<living.size();k+=2)
                        {
                            first=living[k];
                            second=living[k+1];
                            if(first==x && second==y)
                            {
                                flag=1;
                                break;
                            }
                        }
                    }
                }
                if(flag==0)
                {
                    living.push_back(x);
                    living.push_back(y);
                    //print_deq(living);
                }
            }
        }
    }
}

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        }
    }
}
j++;
}
}
//print_deq(living);
}

```

```

void file_print(int* ar, int n, vector<int> simptom_vec)
{
    int row=sqrt(n);
    int col=sqrt(n);
    FILE* fp=fopen("raffaele_samples.txt","a");
    fprintf(fp,"print_counter= %d\n",print_counter);
    print_counter++;
    for(int i=0;i<n;i++)
    {
        fprintf(fp,"%d ",ar[i]);
    }
    fprintf(fp,"\n");
    for(int i=0;i<simptom_vec.size();i++)
    {
        fprintf(fp,"%d ",simptom_vec[i]);
    }
    fprintf(fp,"\n");
    fprintf(fp,"max life= %d",life_pop_max);
    fprintf(fp,"\n");
    fprintf(fp,"life_pop\n");
    for(int i=0;i<life_pop.size();i++)
    {
        fprintf(fp,"%d ",life_pop[i]);
    }
    fprintf(fp,"\n");
    fprintf(fp,"life_exp\n");
    for(int i=0;i<life_exp.size();i++)
    {
        fprintf(fp,"%d ",life_exp[i]);
    }
    fprintf(fp,"\n");
    for(int j=0;j<n;j++)
    {
        if(ar[j]==1)
        {
            fprintf(fp,"o ");
        }
        else
        {
            fprintf(fp,"_ ");
        }
        if((j+1)%row==0)
        {
            fprintf(fp,"\n");
        }
    }
    fprintf(fp,"\n");
    fclose(fp);
}

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void file_print_vec(vector<int> index_mass,char mystr[])
{
    FILE* fp=fopen("raffaele_samples.txt","a");
    fprintf(fp,"%s\n",mystr);
    for(int i=0;i<index_mass.size();i++)
    {
        fprintf(fp,"%d ",index_mass[i]);
    }
    fprintf(fp,"\n ----- \n");
    fclose(fp);
}
void file_print_num(int num,char mystr[])
{
    FILE* fp=fopen("raffaele_samples.txt","a");
    fprintf(fp,"%s= %d\n",mystr,num);
    fclose(fp);
}

void life(int &life_kolvo)
{
    int first,second,alive_sosed,flag;
    int first_new,second_new;
    //deque<int> new_life;
    //deque<int> old_life;
    //print_deq_living(living);
    //cout<<"test1"<<endl;
    //cout<<endl<<endl;
    for(int k=0;k<living.size();k+=2)
    {
        first=living[k];
        second=living[k+1];
        alive_sosed=0;
        for(int i=first-1;i<=first+1;i++)
        {
            for(int u=second-1;u<=second+1;u++)
            {
                //i==first && u==second
                if(i!=first || u!=second)
                {
                    //M[i][u] does not exist = dead
                    if(i<0 || i>=roww || u<0 || u>=coll)
                    {

                    }
                    //M[i][u] exists but dead
                    else if(MM[i][u]==0)
                    {

                    }
                    //M[i][u] exists and alive
                    else if(MM[i][u]==1)
                    {
                        alive_sosed++;
                    }
                }
            }
        }
    }
}

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}

//cout<<"test2 "<<k<<endl;
//creation of life
//cout<<"cell = "<<first<<" "<<second<<" MM="<<MM[first][second]<<" sosed =
"<<alive_sosed<<endl;
//cout<<"test2 "<<k<<endl;
if(alive_sosed==3 && MM[first][second]==0)
{
    new_life.push_back(first);
    new_life.push_back(second);
}
else if(MM[first][second]==1 && (alive_sosed>3 || alive_sosed<2))
{
    old_life.push_back(first);
    old_life.push_back(second);
}
}
//cout<<"test3"<<endl;
//correcting living
//cout<<"living"<<endl;
//print_deq(living);

////cout<<"new_life"<<endl;
////print_deq2(new_life);

////cout<<"living"<<endl;
////print_deq2(living);

for(int k=0;k<new_life.size();k+=2)
{
    first=new_life[k];
    second=new_life[k+1];
    MM[first][second]=1;

    for(int x=first-1;x<=first+1;x++)
    {
        for(int y=second-1;y<=second+1;y++)
        {
            flag=0;
            for(int k=0;k<living.size();k+=2)
            {
                first_new=living[k];
                second_new=living[k+1];
                if(first_new==x && second_new==y)
                {
                    flag=1;
                    break;
                }
            }
        }

        if(flag==0)
        {
            flag=0;
            for(int k=0;k<living_candidats.size();k+=2)
            {
                first_new=living_candidats[k];
                second_new=living_candidats[k+1];
                if(first_new==x && second_new==y)
                {

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        flag=1;
        break;
    }
}

if(flag==0)
{
    living_candidats.push_back(x);
    living_candidats.push_back(y);
}
}
}
}
}

///cout<<"living_candidats medium"<<endl;
///print_deq2(living_candidats);

for(int k=0;k<old_life.size();k+=2)
{
    first=old_life[k];
    second=old_life[k+1];
    MM[first][second]=0;
}

//EXPANSION
int max_x,max_y,min_x,min_y;
int flag1=0, flag_expand_compress=0;
for(int i=0;i<roww && flag1==0;i++)
{
    for(int u=0;u<coll && flag1==0;u++)
    {
        if(MM[i][u]==1 && flag1==0)
        {
            min_x=i;
            flag1=1;
            flag_expand_compress=1;
        }
    }
}
flag1=0;
for(int i=roww-1;i>=0 && flag1==0;i--)
{
    for(int u=coll-1;u>=0 && flag1==0;u--)
    {
        if(MM[i][u]==1 && flag1==0)
        {
            max_x=i;
            flag1=1;
            flag_expand_compress=1;
        }
    }
}
flag1=0;
for(int i=coll-1;i>=0 && flag1==0;i--)
{
    for(int u=roww-1;u>=0 && flag1==0;u--)
    {
        if(MM[u][i]==1 && flag1==0)
        {

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        max_y=i;
        flag1=1;
        flag_expand_compress=1;
    }
}
}
flag1=0;
for(int i=0;i<coll && flag1==0;i++)
{
    for(int u=0;u<roww && flag1==0;u++)
    {
        if(MM[u][i]==1 && flag1==0)
        {
            min_y=i;
            flag1=1;
            flag_expand_compress=1;
        }
    }
}

////cout<<"print_matrix before EXPAND"<<endl;
////print_matrix(MM,roww,coll);

//-----
//cout<<"-----"<<endl;
//print_deq_living(living);
//cout<<"-----"<<endl;
int flag_mass_expand_compress[4]={0,0,0,0};
//cout<<"max_x="<<max_x<<" max_y="<<max_y<<" min_x="<<min_x<<" min_y="<<min_y<<"
roww="<<roww<<" coll="<<coll<<endl;
if(flag_expand_compress==1)
{
    //cout<<"()()()()()coll="<<coll<<" roww="<<roww<<" max_x="<<max_x<<"
    min_x="<<min_x<<" max_y="<<max_y<<" min_y="<<min_y<<endl;
    //expand M to new life
    if(max_y==coll-1)
    {
        MM=expansion_E(MM,&rr,roww,coll,1,1,0);
        life_exp.push_back(1);
        flag_mass_expand_compress[0]=1;
    }
    else if(max_y<=coll-3)
    {
        //cout<<"E_comp="<<(coll-3-max_y+1)*(-1)<<endl;
        life_exp.push_back((coll-3-max_y+1)*(-1));
        MM=expansion_E(MM,&rr,roww,coll,coll-3-max_y+1,-1,0);
        flag_mass_expand_compress[0]=1;
    }
    else if(flag_mass_expand_compress[0]==0)
    {
        life_exp.push_back(0);
    }
}
//cout<<"print_matrix after EXPAND1"<<endl;
//print_matrix(MM,roww,coll);

if(min_y==0)
{
    MM=expansion_W(MM,&rr,roww,coll,1,1,0);
    coord_recalc(1,1);
    coord_recalc_candidates(1,1);
}

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        max_y++;
        min_y++;
        life_exp.push_back(1);
        flag_mass_expand_compress[1]=1;
    }
    else if(min_y>=2)
    {
        //cout<<"W_comp="<<(min_y-2+1)*(-1)<<endl;
        life_exp.push_back((min_y-2+1)*(-1));
        MM=expansion_W(MM,&rr,roww,coll,min_y-2+1,-1,0);
        //coord_recalc(1,-1);
        //coord_recalc_candidates(1,-1);
        coord_recalc(1,-(min_y-2+1));
        coord_recalc_candidates(1,-(min_y-2+1));
        max_y--;
        min_y--;
        flag_mass_expand_compress[1]=1;
    }
    else if(flag_mass_expand_compress[1]==0)
    {
        life_exp.push_back(0);
    }
    //cout<<"print_matrix after EXPAND2"<<endl;
    //print_matrix(MM,roww,coll);

    if(max_x==roww-1)
    {
        //cout<<"-----coll="<<coll<<" roww="<<roww<<" max_x="<<max_x<<endl;
        MM=expansion_S(MM,&rr,roww,coll,1,1,0);
        life_exp.push_back(1);
        flag_mass_expand_compress[2]=1;
    }
    else if(max_x<=roww-3)
    {
        //cout<<"S_comp="<<(roww-3-max_x+1)*(-1)<<endl;
        life_exp.push_back((roww-3-max_x+1)*(-1));
        //cout<<"coll="<<coll<<" roww="<<roww<<" max_x="<<max_x<<endl;
        MM=expansion_S(MM,&rr,roww,coll,roww-3-max_x+1,-1,0);
        flag_mass_expand_compress[2]=1;
    }
    else if(flag_mass_expand_compress[2]==0)
    {
        life_exp.push_back(0);
    }
    //cout<<"print_matrix after EXPAND3"<<endl;
    //print_matrix(MM,roww,coll);

    if(min_x==0)
    {
        //cout<<"+++++++coll="<<coll<<" roww="<<roww<<"
max_x="<<max_x<<endl;
        MM=expansion_N(MM,&rr,roww,coll,1,1,0);
        coord_recalc(-1,1);
        coord_recalc_candidates(-1,1);
        max_x++;
        min_x++;
        life_exp.push_back(1);
        flag_mass_expand_compress[3]=1;
    }
    else if(min_x>=2)

```

```

    {
        //cout<<"N_comp="<<(min_x-2+1)*(-1)<<endl;
        life_exp.push_back((min_x-2+1)*(-1));
        MM=expansion_N(MM,&rr,roww,coll,min_x-2+1,-1,0);
        //coord_recalc(-1,-1);
        //coord_recalc_candidates(-1,-1);
        coord_recalc(-1,-(min_x-2+1));
        coord_recalc_candidates(-1,-(min_x-2+1));
        max_x--;
        min_x--;
        flag_mass_expand_compress[3]=1;
    }
    else if(flag_mass_expand_compress[3]==0)
    {
        life_exp.push_back(0);
    }
    //cout<<"print_matrix after EXPAND"<<endl;
    //print_matrix(MM,roww,coll);
//-----
    //compression of M with empty columns and rows on edges

}

////cout<<"print_matrix after EXPAND"<<endl;
////print_matrix(MM,roww,coll);

//living_candidats should be here
////cout<<"living last1"<<endl;
////print_deq2(living);

////cout<<"living_candidats last"<<endl;
////print_deq2(living_candidats);

for(int i=0;i<living_candidats.size();i+=2)
{
    living.push_back(living_candidats[i]);
    living.push_back(living_candidats[i+1]);
}

////cout<<"living last2"<<endl;
////print_deq2(living);

//OUT RANGE cleaning - NESSESARY
//because "main array" cutting on the top, but "living array" can cut only here

////cout<<"-----OUT RANGE cleaning---roww="<<roww<<"
coll="<<coll<<"-----"<<endl;
for(int i=0;i<living.size();i+=2)
{
    first=living[i];
    second=living[i+1];
    if(first<0 || second<0 || first>=roww || second>=coll)
    {
        ////cout<<"-----OUT RANGE cleaning---first="<<first<<"
second="<<second<<"-----"<<endl;

        living.erase(living.begin()+i);
        living.erase(living.begin()+i);
    }
}

```



```

        i-=2;
    }
}

//killing should be here
///cout<<"KILLING roww="<<roww<<" coll="<<coll<<endl;

for(int k=0;k<living.size();k+=2)
{
    first=living[k];
    second=living[k+1];

    //if(first<0 || second<0 || first>=roww || second>=coll)
    //{
    //    cout<<"k="<<k<<" first="<<first<<" second="<<second<<endl;
    //}

    alive_sosed=0;
    for(int i=first-1;i<=first+1 && i<roww;i++)
    {
        for(int u=second-1;u<=second+1 && u<coll;u++)
        {
            //i==first && u==second
            if(i!=first || u!=second)
            {
                //M[i][u] does not exist = dead
                if(i<0 || i>=roww || u<0 || u>=coll)
                {

                }

                //M[i][u] exists but dead
                else if(MM[i][u]==0)
                {

                }

                //M[i][u] exists and alive
                else if(MM[i][u]==1)
                {
                    alive_sosed++;
                }
            }
        }
    }

    if(MM[first][second]==0 && alive_sosed==0)
    {
        //cout<<"ki_ca"<<endl;
        //print_deq2(killing_candidats);
        killing_candidats.push_back(k);
    }
}

//cout<<"killing_candidats"<<endl;
//print_deq2(killing_candidats);

for(int i=killing_candidats.size()-1;i>=0;i--)
{
    living.erase(living.begin()+killing_candidats[i]);
    living.erase(living.begin()+killing_candidats[i]);
}

```

```

        //cout<<"living_after"<<endl;
        //print_deq2(living);

        //cout<<"++++++++++++"<<endl;
        //print_deq_living(living);

//cout<<"++++++++++++"<<endl;
//print_deq_living(living);

////cout<<"living_recalc"<<endl;
////print_deq2(living);

//cout<<"new="<<new_life.size()/2<<" old="<<old_life.size()/2<<" life_kolvo="<<life_kolvo<<endl;
//print_deq(old_life);
life_kolvo+=new_life.size()/2-old_life.size()/2;
}
void create_memory(int n)
{
    free(MM);
    free(rr);
    life_pop_max=0;
    roww=sqrt(n)+2;
    coll=sqrt(n)+2;
    MM=(int**)calloc(roww,sizeof(int*));
    rr=(int*)calloc(roww*coll,sizeof(int));
    //MM=new int*[roww];
    //rr=new int[roww*coll];
    //cout<<"rr="<<rr<<endl;
    for(int i=0;i<roww;i++)
    {
        MM[i]=rr+i*coll;
    }
    for(int i=0;i<roww;i++)
    {
        for(int u=0;u<coll;u++)
        {
            MM[i][u]=0;
        }
    }
}
//compare 4 numbers down from i and j
int compare_mass(int i, int j, vector<int> index_mass)
{
    //E W S N
    int result;
    int k, flag;
    if(i<0 || j<0)
    {
        result=-1;
    }
    else
    {
        result=1;
        if(result ==1 && index_mass[3]==1)
        {
            if(life_exp[i]!=life_exp[j])
            {
                result=0;
            }
        }
    }
}

```

```

    }
}
if(result ==1 && index_mass[2]==1)
{
    if(life_exp[i-1]!=life_exp[j-1])
    {
        result=0;
    }
}
if(result ==1 && index_mass[1]==1)
{
    if(life_exp[i-2]!=life_exp[j-2])
    {
        result=0;
    }
}
if(result ==1 && index_mass[0]==1)
{
    if(life_exp[i-3]!=life_exp[j-3])
    {
        result=0;
    }
}
//preventing case with only 0
if(result ==1)
{
    k=0;
    flag=0;
    while(k<4)
    {
        if(index_mass[3-k]==1 && life_exp[k]!=0)
        {
            flag=1;
            break;
        }
        k++;
    }
    if(flag==0)
    {
        result=0;
    }
}
}
}

return result;
}
int compare_mass_bloc(int position, int flag_dif_mass[], vector<int> index_mass)
{
    for(int j=0;j<4;j++)
    {
        if(index_mass[j]==1)
        {
            if(life_exp[position+j]!=flag_dif_mass[j])
            {
                return 0;
            }
        }
    }
}
return 1;

```

```

}
void appropriate(vector<int> index_mass, int flag_dif_mass[], int position)
{
    for(int i=0;i<4;i++)
    {
        if(index_mass[i]==0)
        {
            flag_dif_mass[i]=0;
        }
        else
        {
            flag_dif_mass[i]=life_exp[position+i];
        }
    }
}
int flight_step(int flag_syptom, vector<int> index_mass)
{
    int flag_dif_mass[4]={0,0,0,0};
    int flag_dif=-1;
    int last_element=life_exp.size()-1;
    int flag;
    int number_of_periods=20;
    int nop;
    for(int i=life_exp.size()-1;i>0;i-=4)
    {
        //cout<<"-----"<<endl;
        //cout<<"i="<<i<<endl;
        //cout<<"flag_dif="<<flag_dif<<endl;
        //print_ar_norm(flag_dif_mass,4);
        if(i!=life_exp.size()-1 && compare_mass(i,last_element,index_mass)==1 && flag_syptom==0)
        {
            //file_print_num(i,"i");
            //file_print_num(last_element,"last_element");

            //cout<<"life_pop[i]= "<<life_pop[i-(life_pop.size()-2-i)]<<endl;

            //cout<<"----- hvost[...]"<<endl;
            //cout<<"life_pop.size()="<<life_pop.size()<<endl;
            //printf("printf u=%d\n",i - (life_exp.size()-1-i)+1+3);
            //cout<<" u="<<i-(life_pop.size()-1)*4+1-i<<endl;
            if(life_exp.size()-1-i>life_exp.size()/2)
            {
                flag_syptom=-1;
            }
        }
        else
        {
            flag=0;
            //print_vec(index_mass);
            //printf("u=%d\n",i-(life_exp.size()-1-i));
            //print_vec(life_exp);
            //print_matrix(MM,roww,coll);
            //cout<<"-----"<<endl;
            //file_print_num(i-(life_exp.size()-1-i)+1+3,"u");
            //file_print_num(i,"i");
            nop=1;
            while(nop<=number_of_periods)
            {
                for(int u=i-(life_exp.size()-1-i)*nop+1+3;u<i-(life_exp.size()-1-i)*(nop-1);u+=4)
                {

```

```

//if(life_pop[u]!=life_pop[u+life_pop.size()-1-i])
//if(compare_mass(u,u+(life_pop.size()-1-i)*4,index_mass)==0)
//file_print_num(u,"u");
//file_print_num(u+life_exp.size()-1-i,"u_next");
if(compare_mass(u,u+life_exp.size()-1-i,index_mass)<=0)
{

    /*if(life_exp.size()-1-i>life_exp.size()/2)
    {
        flag_symptom=-1;
    }*/
    flag=1;
    break;
}
}
nop++;
}
int counter;
if(flag==0 && flag_dif==-2)
{
    //file_print_vec(index_mass,"index_mass");
    //file_print_vec(life_exp,"life_exp");
    for(int g=0;g<4;g++)
    {
        if(index_mass[g]==1)
        {
            counter=0;
            for(int h=i+1+g;h<life_exp.size();h+=4)
            {
                counter+=life_exp[h];
            }
            if(counter>0)
            {
                flag_symptom=1;
                break;
            }
            else
            {
                flag_symptom=-1;
                break;
            }
        }
        break;
    }
}
}

```

```

/*int f=0;
for(int h=i+1;h<i+1+3;h++)
{
    counter=0;
    if(index_mass[f]==1)
    {
        for(int g=h;g<=life_exp.size()-1-(3-f);g+=4)
        {
            counter+=life_exp[g];
        }
        if(counter>0)
        {

```

```

        flag_syptom=1;
        break;
    }
    else
    {
        flag_syptom=-1;
        break;
    }
    }
    f++;
}*/
}
}

//cout<<endl<<"-----"<<endl;
//cout<<"flag="<<flag<<endl;

}
else
{
    /*if(flag_dif==-1)
    {
        flag_dif=life_pop[i];
    }
    else if(flag_dif!=i)
    {
        flag_dif=-2;
    }*/

    if(flag_dif==-1)
    {
        //flag_dif=life_pop[i];
        appropriate(index_mass,flag_dif_mass,life_exp.size()-4);
        //flag_dif_mass
        flag_dif=0;
    }
    else if(flag_dif==0 && compare_mass_bloc(i-3,flag_dif_mass,index_mass)==0)
    {
        flag_dif=-2;
    }
}
}
return flag_syptom;
}

int life_proverka(int* ar, int n)
{
    int stop=0;
    vector<int> simptom_vec;
    simptom_vec.insert(simptom_vec.end(), {0,0,0,0});
    // 0- in progress
    // 1- found
    // -1- not found

    //10 consecutive
    int counter=1;
    //period
    int last_element=life_pop[life_pop.size()-1];
    int flag;

```

```

int flag_dif=-1;
//vector<int> hvost;

for(int i=life_pop.size()-1;i>=0;i--)
{
    //10 consecutive
    if(counter==100)
    {
        simptom_vec[0]=1;
    }
    if(life_pop[i]==life_pop[i-1] && simptom_vec[0]==0)
    {
        counter++;
    }
    else if(simptom_vec[0]!=1)
    {
        simptom_vec[0]=-1;
    }
}
//-----
//period
//life_pop= 3 1 1 3 1 1 3 1 1
if(i!=life_pop.size()-1 && life_pop[i]==last_element && simptom_vec[1]==0)
{
    //cout<<"life_pop"<<endl;
    //print_vec(life_pop);
    //cout<<"hvost"<<endl;
    //print_vec(hvost);
    //cout<<"life_pop[i]= "<<life_pop[i-(life_pop.size()-2-i)]<<endl;
    flag=0;
    //cout<<"----- hvost[...]"<<endl;
    if(life_pop.size()-1-i>life_pop.size()/2)
    {
        simptom_vec[1]=-1;
    }
    else
    {
        for(int u=i-(life_pop.size()-2-i);u<i;u++)
        {
            //cout<<hvost[hvost.size()-(u-(i-(life_pop.size()-2-i)))-1]<<" ";
            if(life_pop[u]!=life_pop[u+life_pop.size()-1-i])
            {
                //if(life_pop.size()-1-i>life_pop.size()/2)
                //{
                //    simptom_vec[1]=-1;
                //}
                flag=1;
                break;
            }
        }
    }

    //cout<<endl<<"-----"<<endl;
    if(flag==0 && flag_dif==2)
    {
        simptom_vec[1]=1;
    }
}
else
{
    if(flag_dif==1)

```

```

        {
            flag_dif=life_pop[i];
        }
        else if(flag_dif!=life_pop[i])
        {
            flag_dif=-2;
        }
    }
//-----
//big
    if(life_pop[i]>=100)
    {
        simptom_vec[2]=1;
    }
    if(life_pop[i]>life_pop_max)
    {
        life_pop_max=life_pop[i];
    }
}
//-----
//flight
//E W S N
int E,W,S,N;
vector<int> E_d;
vector<int> W_d;
vector<int> S_d;
vector<int> N_d;
vector<int> ES_d;
vector<int> EN_d;
vector<int> WS_d;
vector<int> WN_d;
E_d.insert(E_d.end(), {1,0,0,0});
W_d.insert(W_d.end(), {0,1,0,0});
S_d.insert(S_d.end(), {0,0,1,0});
N_d.insert(N_d.end(), {0,0,0,1});
ES_d.insert(ES_d.end(), {1,0,1,0});
EN_d.insert(EN_d.end(), {1,0,0,1});
WS_d.insert(WS_d.end(), {0,1,1,0});
WN_d.insert(WN_d.end(), {0,1,0,1});
int stop_flight=0;
int flag_mass[8]={0,0,0,0,0,0,0,0};
//int* index_mass[4]={0,0,0,0};

flag_mass[0]=flight_step(flag_mass[0], E_d);
flag_mass[1]=flight_step(flag_mass[1], W_d);
flag_mass[2]=flight_step(flag_mass[2], S_d);
flag_mass[3]=flight_step(flag_mass[3], N_d);
//flag_mass[4]=flight_step(flag_mass[4], ES_d);
//flag_mass[5]=flight_step(flag_mass[5], EN_d);
//flag_mass[6]=flight_step(flag_mass[6], WS_d);
//flag_mass[7]=flight_step(flag_mass[7], WN_d);
//print_ar_norm(flag_mass,8);
for(int f=0;f<4;f++)
{
    if(flag_mass[f]==1)
    {
        stop_flight=1;
    }
}

```



```

        simptom_vec[3]=1;
        break;
    }
}

//-----
//cout<<"simptom_vec"<<endl;
//print_vec(simptom_vec);
for(int i=0;i<simptom_vec.size();i++)
{
    if(simptom_vec[i]==1)
    {
        stop=1;
        //if(simptom_vec[2]==1)
        //{
        //    file_print(ar,n,simptom_vec);
        //}
        if(simptom_vec[3]==1)
        {
            file_print(ar,n,simptom_vec);
        }
        break;
    }
}
return stop;
}

void ar_create(int n)
{
    FILE* fp=fopen("raffaele_samples.txt","w");
    fclose(fp);
    create_memory(n);

    //-----
    int life_kolvo;
    int* ar=(int*)calloc(n,sizeof(int));
    //int* ar=new int(n);
    int flag=0;
    for(int i=0;i<n;i++)
    {
        ar[i]=0;
    }
    int counter=0;
    int w;
    while(flag==0)
    {
        flag=1;
        //print_ar(ar,n);
        living.clear();

        //cout<<"-----"<<endl;
        //cout<<"---- combination num "<<counter<<"-----"<<endl;
        //if(counter>0 && counter<5)
        //{
        fill_matrix(MM,roww,coll,ar);
        //print_matrix(MM,roww,coll);
        life_kolvo=count_life_kolvo(ar,n);
        w=0;
        int stop=0;
        while(stop==0)

```

```

{
    life(life_kolvo);
    //cout<<"phase"<<endl;
    //print_matrix(MM,roww,coll);
    life_pop.push_back(life_kolvo);
    new_life.clear();
    old_life.clear();
    living_candidats.clear();
    killing_candidats.clear();
    //cout<<"w="<<w<<" life_kolvo="<<life_kolvo<<endl;
    if(life_kolvo<=0)
    {
        break;
    }
    stop=life_proverka(ar, n);
    //if(stop==1)
    //{
    //    break;
    //}
    w++;
}
//print_vec(life_exp);
//print_vec(life_pop);
//cout<<"final stop="<<stop<<" length="<<life_pop.size()<<endl;
//cout<<"final"<<endl;
//print_matrix(MM,roww,coll);
life_exp.clear();
life_pop.clear();
create_memory(n);
//}
for(int i=n-1;i>=0;i--)
{
    if(ar[i]==0)
    {
        ar[i]=1;
        for(int u=i+1;u<n;u++)
        {
            ar[u]=0;
        }
        flag=0;
        break;
    }
}

counter++;
}
}

void experiment_expen()
{
    /*row=3;
    col=5;
    MM=new int*[row];
    rr=new int[row*col];
    for(int i=0;i<row;i++)
    {
        MM[i]=rr+i*col;
    }
    for(int i=0;i<row;i++)
    {

```

```

    for(int u=0;u<col;u++)
    {
        MM[i][u]=0;
    }
}*/

//-----

/*M=expansion_S(M,&r,row,col,6,1,4);
print_matrix(M,row,col);
M=expansion_S(M,&r,row,col,2,1,5);
print_matrix(M,row,col);
M=expansion_S(M,&r,row,col,2,1,9);
print_matrix(M,row,col);*/

//M=expansion_N(M,&r,row,col,4,1,7);
//print_matrix(M,row,col);
//M=expansion_N(M,&r,row,col,2,-1,7);
//print_matrix(M,row,col);

/*M=expansion_E(M,&r,row,col,3,1,1);
print_matrix(M,row,col);
M=expansion_E(M,&r,row,col,2,1,2);
print_matrix(M,row,col);
M=expansion_E(M,&r,row,col,2,1,3);
print_matrix(M,row,col);
M=expansion_E(M,&r,row,col,3,-1,1);
print_matrix(M,row,col);*/

/*MM=expansion_W(MM,&rr,row,col,6,1,6);
print_matrix(MM,row,col);

MM=expansion_W(MM,&rr,row,col,3,-1,4);
print_matrix(MM,row,col);*/

//-----

int ar_temp2[9]={1, 1, 1, 1, 1, 1, 1, 0, 1};
//life_pop.push_back();
//life_pop.insert(life_pop.end(), {19,19,49,59,29,39,49,59,59,29,39,49,59});
//life_pop.insert(life_pop.end(), {19,19,49,59,29,39,59,29,39,49,59});
//life_pop.insert(life_pop.end(), {19,19,49,59,29,39,49,59,59,29,39,49,59});
//life_pop.insert(life_pop.end(), {19,0,0,0,0,0,0,0,1,1});
//print_vec(life_pop);
//{1,1,4,5,2,3,4,5,5,2,3,4,5};
//int stop=life_proverka(ar_temp2,9);
//cout<<endl<<stop<<endl;
//return;

//life_pop.insert(life_pop.end(), {0,0,5,0,1,0,3,0,4});
//life_exp.insert(life_exp.end(), {-1, 1, 0, -2, 1, 1, 0, 1, 1, -1, 0, 1, -1, 1, 0, -2, 1, 1, 0, 1, 1, -1, 0, 1, -1,
1, 0, -2, 1, 1, 0, 1, 1, -1, 0, 1});
life_pop.insert(life_pop.end(), {3,3});
life_exp.insert(life_exp.end(), {0, 0, 1, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0});
int stop=life_proverka(ar_temp2,9);
cout<<endl<<stop<<endl;
//-----
/*int n=9;

```

```

create_memory(n);
int life_kolvo;
int ar_temp[9]={1, 1, 1, 1, 1, 1, 1, 0, 1};
//int* ar=new int(n);
int counter=0;
int w;

print_ar(ar_temp,n);
living.clear();
fill_matrix(MM,roww,coll,ar_temp);
print_matrix(MM,roww,coll);
life_kolvo=count_life_kolvo(ar_temp,n);
w=0;
int stop;
while(w<30)
{
    life(life_kolvo);
    cout<<"phase"<<endl;
    print_matrix(MM,roww,coll);
    life_pop.push_back(life_kolvo);
    new_life.clear();
    old_life.clear();
    living_candidats.clear();
    killing_candidats.clear();
    cout<<"w="<<w<<" life_kolvo="<<life_kolvo<<endl;
    if(life_kolvo<=0)
    {
        break;
    }
    stop=life_proverka(ar_temp, n);
    if(stop==1)
    {
        break;
    }
    w++;
}
print_vec(life_exp);
print_vec(life_pop);
cout<<"stop="<<stop<<" length="<<life_pop.size()<<endl;
cout<<"final"<<endl;
print_matrix(MM,roww,coll);
life_exp.clear();
life_pop.clear();*/
}
//0 0 1 0 1 0 1 1 1
int main()
{
    //life();
    ar_create(16);
    //experiment_expen();
    return 0;
}

```