„Programming”
C3

Made by: Cristea Andrei
Neptun code: W61RAB
E-mail: cristea.andrei997@gmail.com

Course code: ?????
Teacher’s name: ???

2020. June 05

Content

User documentation

Task

Task Name : Continuously the warmest settlement

We have the weather forecast for the next N days for M settlements.

Write a program that gives the warmest settlement. The warmest settlement is the settlement which has the most count of days when its temperature is higher than temperatures of all the other settlements.

Runtime environment

A Macbook Pro 2014 that is run on Mac OS 64 system. For running program you can use any other operating system. No mouse needed.

Usage

Starting the program

The program can be found in the archived file by the name: `warmest\program\warmest.exe`
If you are using Linux/ Mac OS: `warmest\program\warmest.out`

You can start the program by clicking the `warmest.exe` file.

Program input

The program reads the input data from the keyboard in the following order:

#	Data	Explanation
1.	*N*	Number of days weather was forecasted (1 <= N <= 1000).
2.	*M*	Count of settlements (0 <= M <= 1000).
3.	*L*	A temperature limit (20 <= L <= 50).
...	...	
(N+1)*(M+1)	$temperature_{N,M}$	The N^{th} settlements the M^{th} days temperature (0 <= temperature <=50).

Program output

The program writes out the index of settlement which is the hottest in human readable format(<=1) . The hottest settlement is the one which has the most count of days when the temperature is hotter then in selected day in other settlements.
If there is multiple solutions output should be the one with the smallest index

Sample input and output

```
====Continuosly warmest settlement====
Please write down settlements, days and temperature limit
Separate each input by new line
Settlement
5
Day
6
Temperature Limit
30
Next, write down in each column settlement's temperature:
20 22 22 24 26 21
31 31 31 29 31 20
20 30 35 30 30 21
32 29 34 32 29 30
33 20 20 33 33 30
The warmest settlement is:
5
```

Possible errors

The input should be given according to the sample. If the number of measurements is not a whole number, or it is not in the range 2..10000, it will cause a problem. If one of the measurements is not a number, or it is not in the range 0..9000, it also will cause a problem. In the case of an error, the program displays an error message, or asks for the repetition of the input. There are two types of streams in input for the program: integer values and array values. In order to ease debugging process and to paste big data inside array of temperatures second input validation function will work with getline from STL. Samples of invalid data validation is below.

Sample of running in the case of invalid data for settlement, day and temperature limit:

Inputs which can't be validated for N, M and L:

- Integer is out of range for e.g. range can be: [1..1000]
- Any other types except integer
- More than one integer in a line

```
====Continuosly warmest settlement====
Please write down settlements, days and temperature limit
Separate each input by new line
Settlement
als
Error. Enter integer value
Try again
2300
Error. Your integer value is out of bound
Try again
Settlement
3.42
Error. Enter integer value
Try again
2Lol
Error. Enter integer value
Try again
2 3
Error. Enter integer value
Try again
5
Day
Wednesday
Error. Enter integer value
Try again
3000
Error. Your integer value is out of bound
Try again
Day
30 30
Error. Enter integer value
Try again
6
Temperature Limit
Limit
Error. Enter integer value
Try again
1001
Error. Your integer value is out of bound
Try again
Temperature Limit
51
Error. Your integer value is out of bound
Try again
Temperature Limit
30
Next, write down in each column settlement's temperature:
```

Sample of running in the case of invalid data for temperature sequence. Here validator checks entire line for the error.

Inputs which can't be validated for weather$_{1..N,1..M}$:

- Integers are out of range: [0..50]
- Any other types except integers
- Ignores Values which are out of array size

```
====Continuosly warmest settlement====
Please write down settlements, days and temperature limit
Separate each input by new line
Settlement

5
Day
df
Error. Enter integer value
Try again
6
Temperature Limit
30
Next, write down in each column settlement's temperature:
20 22 22 24 26 wrong+here
Error. Input should be integer
Error found in line.
All temperatures in settlement should be in range 0<=Temperature<=50
Try again
55 20 23 23 23 1
Error found in line.
All temperatures in settlement should be in range 0<=Temperature<=50
Try again
20 22 22 24 26 21 12
31 31 31 29 31 20
20 30 35 30 30 21
32 29 34 32 29 30
33 20 20 33 33 30
The warmest settlement is:
5
```

Developer documentation

Task

We have the weather forecast for the next N days for M settlements.

Write a program that gives the warmest settlement. The warmest settlement is the settlement which has the most count of days when its temperature is higher than temperatures of all the other settlements.

Remark:
If there is multiple solutions output should be the one with the smallest index

Specification

Input: N, M, L $\in$ N, $weather_{1..N,1..M} \in N^{N*M}$

Output: biggest $\in$ N

Precondition: N = [1..1000] $\wedge$ M = [1..1000] $\wedge$ L=[20..50]

Postcondition: $\forall$j(1<=j<=M) and $\forall$i(1<=i<=N): $transpose_{j,i} = weather_{i,j}$ $\vee$

1<= MaxInd <= N and $\forall$j(1<=i<=M) and $\forall$i(1<=j<=N): $transpose_{i, maxInd} > transpose_{i, j}$ and max = $transpose_{i, maxInd}$ and index = j and has_no_duplicates($transpose_i$, j,$transpose_{i,j}$) and max > L
$\forall$j(1<=i<=M) and $\forall$i(1<=j<=N): not has_no_duplicates($transpose_i$, j,$transpose_{i,j}$) : duplicates.insert()

$\vee$ ind_dup :=ind_duplicate($transpose_i$) and

$out_{index} = \square_{i=1}^{M} 1$ and $out_{take\_dup\_index(transpose_i, transpose_{i,ind\_dup})} = \square_{i=1}^{M} 1$

max > L or all_less_than_L duplicates.count(i) and $transpose_{i,ind\_dup}$

$\vee$ biggest := take_biggest(out)

Definitions:

has_no_duplicates : Set($transpose_i$) = $transpose_i$
give_biggest: $\forall$i(1<=i<=N): 1<= biggest<= N and $\forall$j(1<=i<=N) :$out_{,i} > cnt_j$ and cnt=out_{maxInd}
take_dup_index: $\exists$i(1<=i<=N) :v[i] = d
find_duplicate: $\exists$j(1<=j<=N) and $\exists$i(1<=i<=N): v[i] = v[j]
all_less_than_L: $\forall$i(1<=i<=M) and $\forall$j(1<=j<=N):$\forall$ v[i][j] <= L

Developer environment

Original Developed Environment:
Macbook Pro, and operating system capable of running .out files(Mac OS Mojave). Apple clang version 11.0.0 (clang-1100.0.33.8) compiler, Xcode(v 11.0) developer tool(mainly used for debugging). Additionally used for input clarification Visual Studio Code(v 1.45.1).

Developer's Recommended Environment
Any operating system with pre-installed compiler g++.
e.g:
IBM PC, an operating system capable of running exe files (eg. Windows 7). mingw32-g++.exe c++ compiler (v4.7), Code::Blocks (v13.12) developer tool.

Source code

All the sources can be found in the *A1B2C3* folder (after extraction). The folder structure used for development:

File	Explanation
warmest\program\warmest.exe	Executable code for Windows
warmest\program\warmest.out	Executable code for Linux & Mac Os
warmest\object\main.o	Semi-compiled code
warmest\main.cpp	C++ source code
warmest\tests\test1.txt	input test file1
warmest\tests\test11.txt	input test file11
warmest\tests\test2.txt	input test file2
warmest\tests\test3.txt	input test file3
warmest\tests\test4.txt	input test file4
warmest\tests\test5.txt	input test file5
warmest\tests\test6.txt	input test file6
warmest\docs\warmest_settlement.docx	documentation (this file)
warmest\docs\warmest_settlement.pdf	documentation (this file) (pdf format)

Solution

Program parameters

Contants

```
min_limit       : Integer(1)
```

```
max_limit       : Integer(1000)
```

Types

```
weather         = Array(1..N:Integer, 1..M: Integer)
transpose       = Array(1..M:Integer, 1..N: Integer)
out             = Array(1..N: Integer)
duplicates      = Set(1..cnt: Integer)
T               = Template
Local(looped types)
temp            = Array(1..split_to_int.size(): Integer)
```

Variables

```
N               : Integer
M               : Integer
L               : Integer
biggest         : Integer
Local(looped variables)
all_less        : Boolean
repeat          : Boolean
str             : String
max             : Integer
index           : Integer
dup_ind         : Integer
```

The structure of the program

The modules used by the program, and their locations:

`main.cpp` – the program, in the source folder

`iostream` – keyboard and console management, part of the C++ system

`vector` – special type of container with useful methods , part of the C++ system

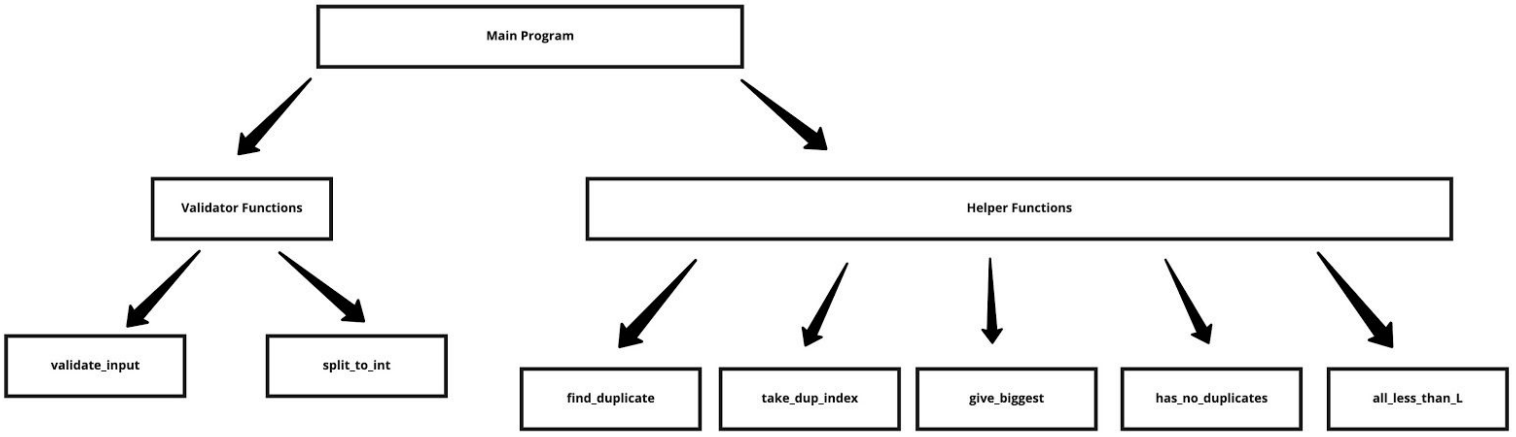
`set` – special type of container in C++ which has same concepts of set as in maths, part of the C++ system

`limits` - defines numeric_limits, part of the C++ system

`string` - header file with functions classes and variable for organizing work with strings, part of the C++ system.

`sstream`- header file with functions classes and variable for organizing work with strings in streams, part of the C++ system.

Structure of function



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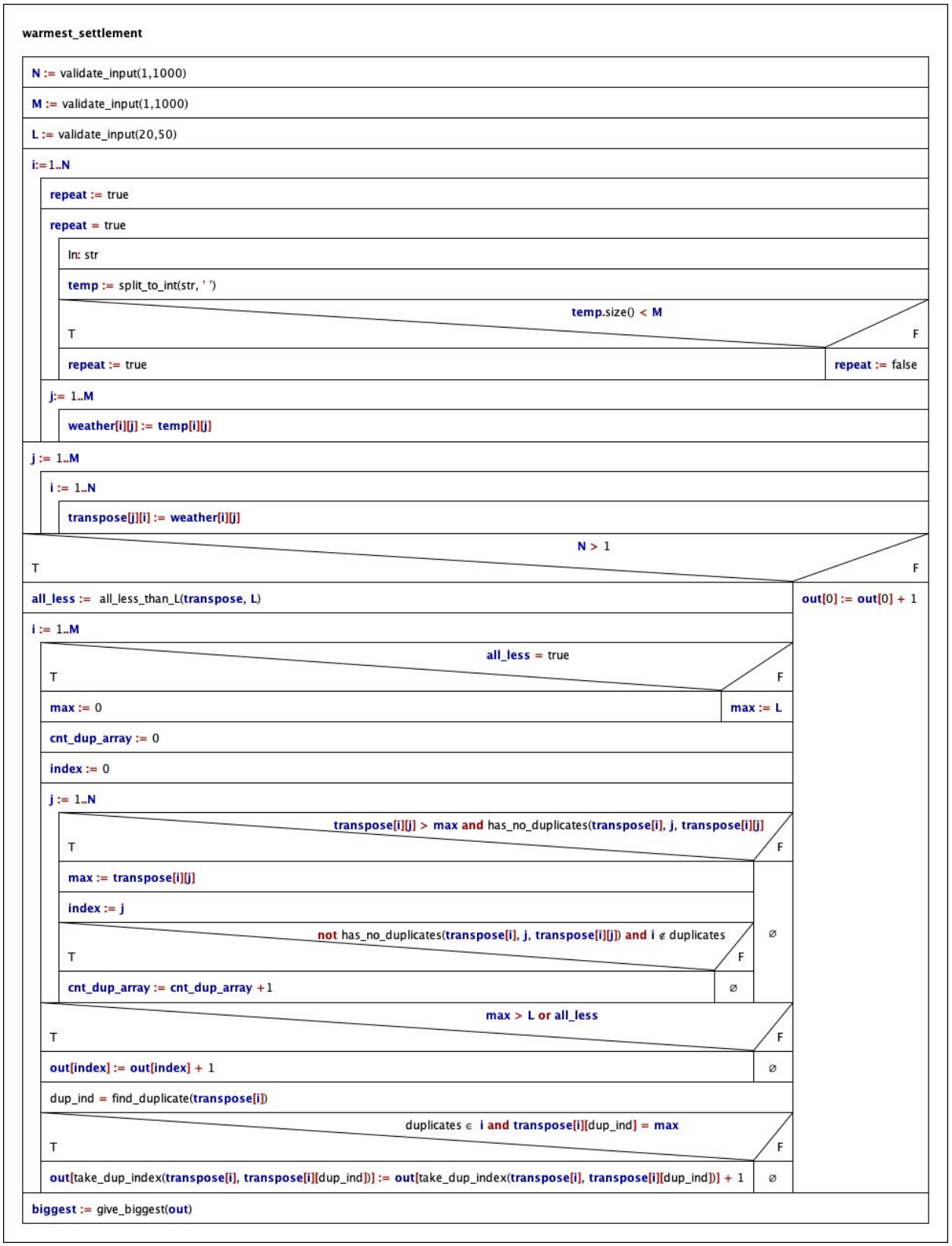
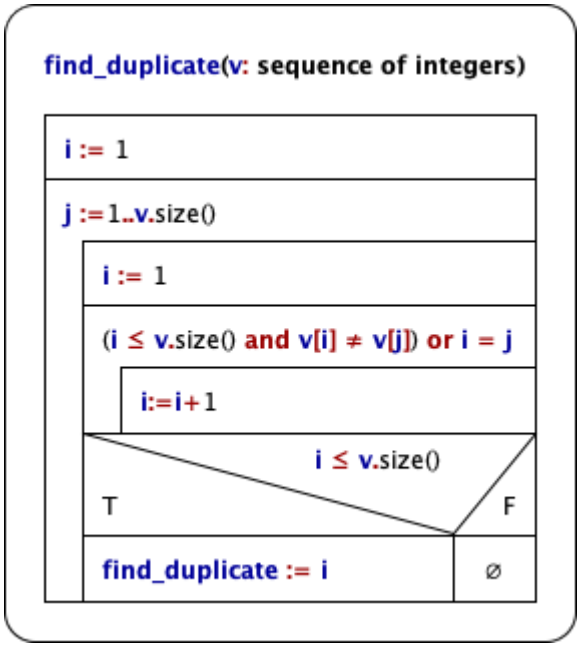
The algorithm of the program

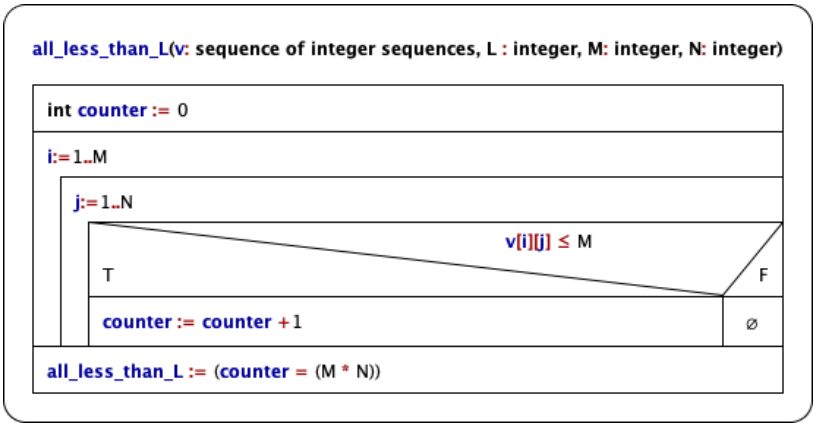
Main program:

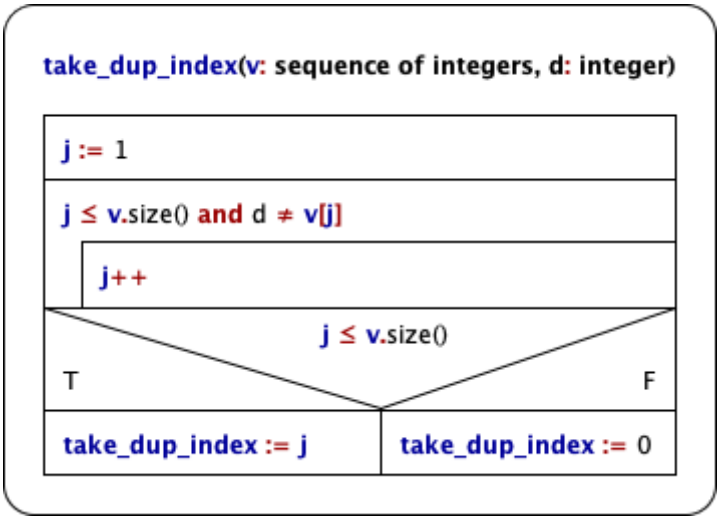


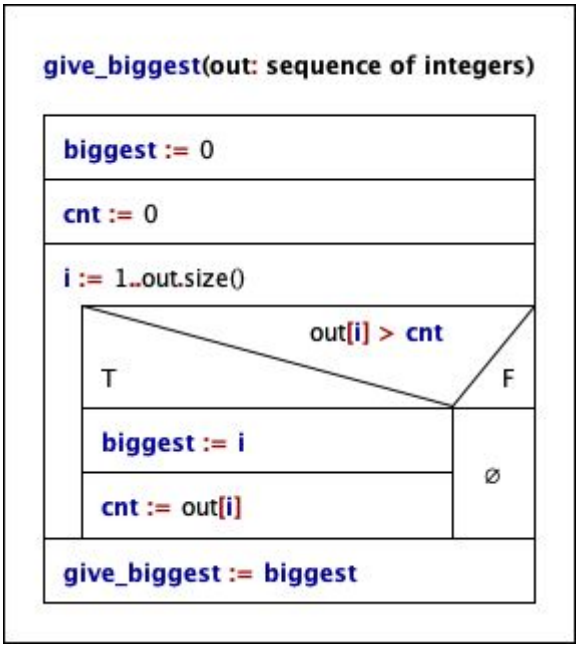
Subprograms:

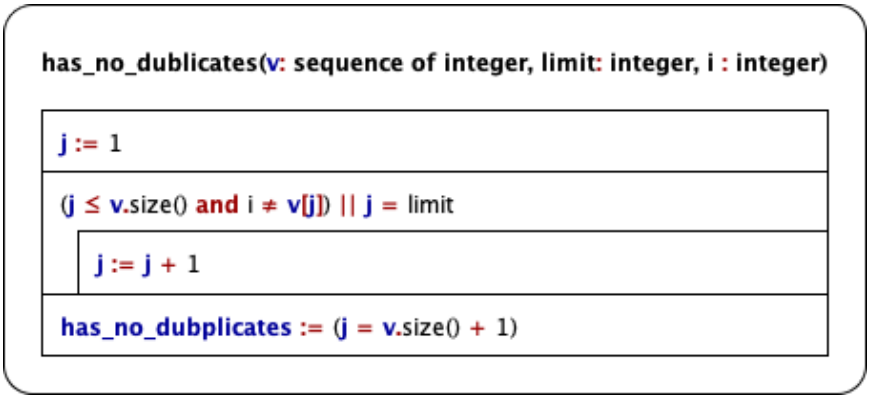
Helper Functions:



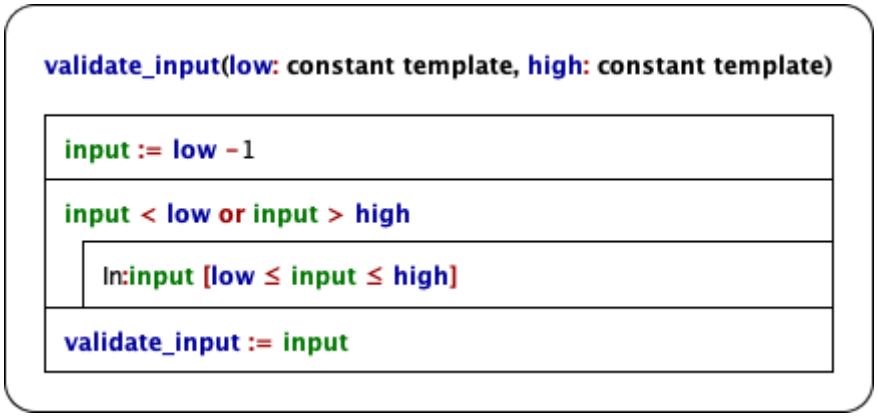


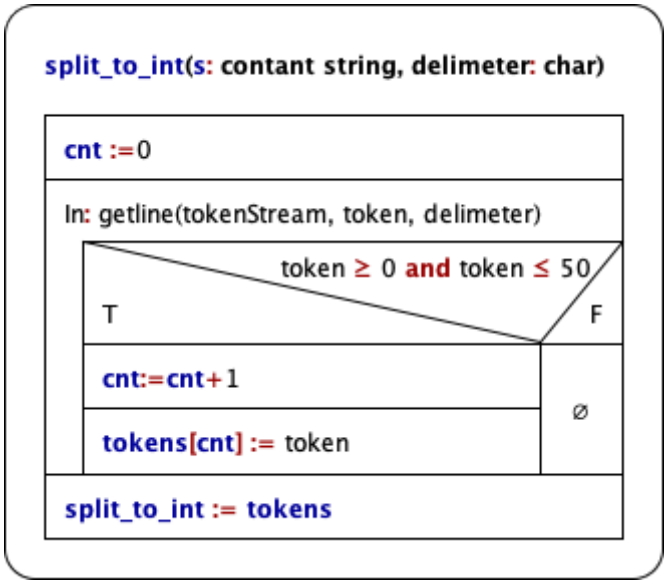






Input Validation Functions:





The code

The content of the `main.cpp` file:

```
/*
Created by: Andrei Cristea
Neptun: W61RAB
E-mail: cristea.andrei997@gmail.com
Task: „C3" - Continuously the warmest settlement
*/

#include <iostream>
#include <vector>
#include <set>
#include <sstream>
#include <limits>
#include <string>

using namespace std;

template <class T>

T validate_input(const T low, const T high, const string &message, const string
&error, const string &mismatch)
{
    T input = low - 1;
    while (input < low || input > high)
    {
        cout << message;
```

```
        while ((cin >> input).fail() || cin.peek() != '\n')
        {
            cin.clear();
            cin.ignore(numeric_limits<streamsize>::max(), '\n');
            cerr << error;
        }
        cin.clear();
        cin.ignore(numeric_limits<streamsize>::max(), '\n');
        if (input < low || input > high)
        {
            cerr << mismatch;
        }
    }
    return input;
}

vector<int> split_to_int(const string &s, char delimeter)
{
    vector<int> tokens;
    string token;
    istringstream tokenStream(s);
    while (getline(tokenStream, token, delimeter))
    {
        try
        {
            if (stoi(token) >= 0 && stoi(token) <= 50)
            {
                tokens.push_back(stoi(token));
```

```
            }
        }
        catch (exception &err)
        {
            cerr << "Error. Input should be integer\n";
            break;
        }
    }
    return tokens;
};

bool all_less_than_L(vector<vector<int> > v, int M){
    int counter = 0;
    for (int i = 0; i < v.size(); i++)
    {
        for(auto vi : v[i]){
            if(vi <= M){
                counter++;
            }
        }
    }
    return (counter == (v.size() * v[0].size()));
}

int find_duplicate(vector<int> v)
{
    int i = 0;
    for (int j = 0; j < v.size(); j++)
```

```
    {
        i = 0;
        while ((i < v.size() && v[i] != v[j]) || i == j)
        {
            i++;
        }
        if (i < v.size())
        {
            break;
        }
    }
    return i;
};

int take_dup_index(vector<int> v, int d)
{
    int j = 0;
    while (j < v.size() && d != v[j])
    {
        j++;
    }
    if (j < v.size())
    {
        return j;
    }
    return 0;
};
```

```
int give_biggest(vector<int> out)
{
    int biggest = 0;
    int cnt = 0;
    for (int i = 0; i < out.size(); i++)
    {
        if (out[i] > cnt)
        {
            biggest = i;
            cnt = out[i];
        }
    }
    return biggest;
};

bool has_no_duplicates(vector<int> v, int limit, int i)
{
    int j = 0;
    while ((j < v.size() && i != v[j]) || j == limit)
    {
        j++;
    }
    return (j == v.size());
};

int main()
{
```

```
int N = 0, M = 0, L = 0;
cout << "====Continuosly warmest settlement====\n";
cout << "Please write down settlements, days and temperature limit\n";
cout << "Separate each input by new line\n";

const int min_limit = 1;
const int max_limit = 1000;
const string type_error = "Error. Enter integer value\nTry again\n";
const string limit_error = "Error. Your integer value is out of bound\nTry again\n";

N = validate_input(min_limit, max_limit, "Settlement\n", type_error, limit_error);
M = validate_input(min_limit, max_limit, "Day\n", type_error, limit_error);
L = validate_input(20, 50, "Temperature Limit\n", type_error, limit_error);

cout << "Next, write down in each column settlement's temperature:\n";
vector<vector<int> > weather(N, vector<int>(M, 0));
for (int i = 0; i < N; i++)
{
    bool repeat = true;
    vector<int> temp;
    while (repeat)
    {
        string str;
        getline(cin, str, '\n');
        temp = split_to_int(str, ' ');
        if (temp.size() < M)
        {
            repeat = true;
```

```
            cerr << "Error found in line.\nAll temperatures in settlement should be in range 0<=Temperature<=50\nTry again\n";
        }
        else
            repeat = false;
    }
    for (int j = 0; j < M; j++)
    {
        weather[i][j] = temp[j];
    }
}

// First, transpose matrix in order to have simplify task
vector<vector<int> > transpose(M);
for (int j = 0; j < M; j++)
{
    for (int i = 0; i < N; i++)
    {
        transpose[j].push_back(weather[i][j]);
    }
}

// Initialize helper data collections
vector<int> out(N);
set<int> duplicates;

// Main computation part
if (N > 1)
```

```
    {
        bool all_less = all_less_than_L(weather, L);
        // looping over transpose matrix in order to find in each column maximum
temperatures
        for (int i = 0; i < transpose.size(); i++)
        {
            int max = 0;
            if (all_less)
            {
                max = 0;
            }else{
                max = L;
            }

            int index = 0;
            for (int j = 0; j < transpose[i].size(); j++)
            {
                // Take maximum temperature, which is unique (biggest temp can not have
duplicates)
                if (transpose[i][j] > max && has_no_duplicates(transpose[i], j, transpose[i][j]))
                {
                    max = transpose[i][j];
                    index = j;
                }
                // Take in count special case, thus take the columns index
                else if (!has_no_duplicates(transpose[i], j, transpose[i][j]))
                {
                    duplicates.insert(i);
```

```
            }
        }
        // increase count of index in out array
        if (max > L || all_less)
        {
            out[index] += 1;
        }
        int dup_ind = find_duplicate(transpose[i]);
        // special case when our duplicated value, decides if the
        // settement is the hottest
        if (duplicates.count(i) && transpose[i][dup_ind] == max)
        {
            out[take_dup_index(transpose[i], transpose[i][dup_ind])]++;
        }
    }
}
else
{
    out[0]++;
}

// take out the index with the biggest value
int biggest = give_biggest(out);

// transer in human readable format
cout << "The warmest settlement is:\n";
cout << biggest + 1 << endl;
return 0;}
```

Testing

Valid test cases

1. test case: test1.txt

Input – *minimal number of days and settlements(1)*

N = 1
M = 1
L = 20
$weather_{11}$ = 1

Output

1

2. test case: test11.txt

Input – *simple case 10*10*

N = 10
M = 10
L = 30
$weather_{11}$ = 1
.
.
.
$weather_{10,10}$ = 10

Output

3
(we don't count warmest because they are out of bound)

3. test case: test6.txt

Input –*warmest settlement has smallest maximum temperatures*

N = 3
M = 4
L = 20
$weather_{11}$ = 21
$weather_{12}$ = 23
$weather_{13}$= 23
$weather_{14}$= 21
$weather_{21}$= 22
$weather_{22}$= 22
$weather_{23}$= 22
$weather_{14}$= 22
$weather_{31}$= 21
$weather_{32}$= 22
$weather_{33}$= 24
$weather_{34}$ = 21

Output

2

4. test case: test2.txt

Input –*warmest settlement has smallest maximum temperatures, but all are smaller than L*

N = 3
M = 4
L = 20
$weather_{11}$ = 1
$weather_{12}$ = 3
$weather_{13}$= 3
$weather_{14}$= 1
$weather_{21}$= 2
$weather_{22}$= 2
$weather_{23}$= 2
$weather_{14}$= 2
$weather_{31}$= 1
$weather_{32}$= 2
$weather_{33}$= 4
$weather_{34}$ =1

Output

2

5. test case: test4.txt

Input – *has two the warmest settlements. We take the one with smaller index*

N = 5
M = 6
L = 30
$weather_{11}$ =20
.
.
.
.
$weather_{56}$ =30

Output

2

6. test case: test3.txt

Input – *Almost indentical to the previos one, expect here 2nd and 3rd settlements are not identical*

N = 5
M = 6
L = 30
$weather_{11}$ =20
.
.
.
.

weather$_{56}$ =30

Output

3

7. test case: test5.txt

Input – *Big data amount. !00*100 matrix*

N = 100
M = 100
L = 47
weather$_{11}$ =46
.
.
.
.
weather$_{100100}$ =43

Output

2

Invalid test cases

8. test case

Input – *wrong settlement type*

N = eleven11

Output

Error. Enter integer value
Try again:
N =

9. test case

Input – *settlement value out of bound*

N=10001

Output

Error. Your integer value is out of bound
Try again
Settlement
N=

10. test case

Input – *day value out of bound*

M=1001

Output

Error. Your integer value is out of bound
Try again
Day
M=

11. test case

Input – *wrong settlement type*

M=wrong

Output

Error. Enter integer value
Try again:
N =
(Same applies for L (with bounds 20 <= L <= 50))

12. test case

Input – *wrong settlement's temperature type*

line= 20 22 22 24 asd 21

Output

Error. Input should be integer
Error found in line.
All temperatures in settlement should be in range 0<=Temperature<=50
Try again
line=

13. test case

Input – *wrong settlement's temperature value*

line= 20 22 22 24 56 -23

Output

Error found in line.
All temperatures in settlement should be in range 0<=Temperature<=50
Try again
line=

Further development options

1. Data to be read from file
2. Detection of wrong file input, writing out the location and ID# of error
3. Capability to run multiple times after each other
4. Visual representation of input data, and emphasizing the result islands with different colors