Arrays

Lab 12: Maze Routing with Two Dimensional Arrays

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Arrays

- One dimensional arrays vs. multi-dimensional arrays.
- How to declare an array?
- How to put data into arrays?
- How to pass arrays to a function?
- How to process data in arrays?

How to declare an array?

- The array size must be known upon declaration.

```
int anIntAry[10];
const int arraySize = 20;
string anStringAry[arraySize];
string aTwoDimStringAry[10][20];
const int numOfRows = 15;
const int numOfColumns = 25;
int aTwoDimIntAry[numOfRows][numOfColumns];
double aThreeDimDoubleAry[10][5][24];
```

How to initialize an array?

- Initialize it once during declaration

```
int anIntAry[5]  = {1,2,3,4,5};
string anStringAry[5] = {“1ST”, “2ND”, “3rd”}
int aTwoIntAry[4][3] ={ };
int antTwoIntAry[4][3] = {{1,2,3},{4,5,6},{7,8,9},{10,11,12}};
int antTwoIntAry[4][3] = {1,2,3,4,5,6,7,8,9,10,11,12};
```

- Initialize it during execution

```
for(int i=0;i<4; i++)
      for(int j=0; j<3; j++)
           aTwoIntAry[i][j] = i+j;
```

	Column 0	Column 1	Column 2
Row 0	0	1	2
Row 1	1	2	3
Row 2	2	3	4
Row 3	3	4	5

Pass arrays to a function in a function call

- Pass by reference, so only the starting address of an array is passed.
- How to specify the starting address of an array?
  - **Use its name or the address of the first element**
    - **For one-dimensional array**
      &arrayOne[0] or arraryOne
    - **For two dimensional array**
      &arrayTwo[0][0] or arrayTwo
    - **For three dimensional array**
      &arrayThree[0][0][0] or arrayThree

Declare an array in a function's parameter list

- **Declare an array in a function prototype**

  The size of each dimension except the first dimension must be given.

```
const int dim1 = 10;
const int dim2 = 20;
const int ndim3 = 30;
void aFunc( int [ ], int x[ ], int y[ ][dim2], int [ ][dim2][dim3],
int);
```

Must be constant integers

- **Declare an array in the parameter list of a function body**

```
void aFunc(int a[ ], int b[ ], int c[ ][dim2], int d[ ][dim2][dim3],
int dim1)
{
...
}
```

Should be dim2 and dim3

Used for specifying the size of the first dimension

It is incorrect to declare a function shown below to pass arrays to the function:
void aFunc(int a[dim1], int b[dim1], int c[dim1][dim2], int d[dim1][dim2][dim3], int dim1)

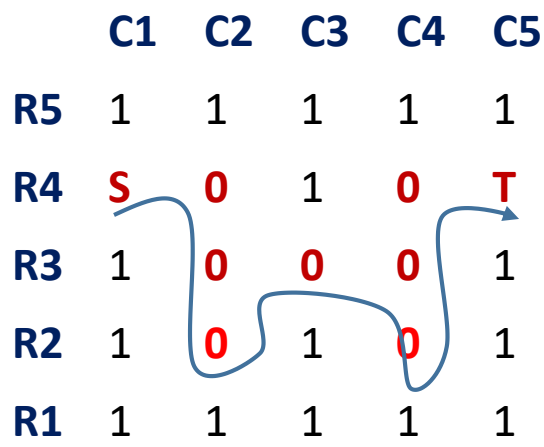
Make calls to a function

```
const int dim1 = 40, dim2 = 20, dim3 = 30;
void aFunc( int [ ], int x[ ], int y[ ][dim2], int [ ][dim2][dim3], int);
int main(){
    int w[28], x[dim1], y[dim1]dim2], z[dim1]dim2][dim3];
    int dim = 28
    aFunc( w, &x[0], &y[0][0], z, dim);
        …
}
void aFunc(int a[ ], int b[ ], int c[ ][dim2], int d[ ][dim2][dim3], int dima)
{
   for(int x=0; x<dima; x++)
        a[x] = x;
   for(int d1=0; d1<dima; d1++){
      b[d1] = d1+2;
      for(int d2=0; d2<dim2; d2++){
         c[d1][d2] = d1 * d2 +13;
         for(int d3=0;d3<dim3; d3++)
            d[d1][d2][d3] = d1+d2 * d3 + 23;
      }
   }
}
```

Lab 12: Maze Routing

- Given a maze of M rows and N columns of grids. Each entry in the maze contains either a 0, 1, S or T, where 1 denotes an obstacle, 0 denotes a free grid, S is a source grid, and T is a target grid. Assume there is only one source and one target grid on the boundary of the maze. Write a program using the algorithm given below to find a path from S to T. Print the total distance travelled and the coordinates (row, column) of the start and target. If no target is found, set the coordinates of target to (-1, -1).

- For example, given the maze on the right, your program should find the path marked with red symbols. The start's and target's coordinates are (4,1) and (4, 5). The curve shows the grids being walked. The distance travelled is 10, which is calculated based on this curve.



- Algorithm

  S1: Set current grid to S and depart from S.

  S2: Following the traveling direction, if the grid on the right of the current grid is free, then turn right and advance to it. Otherwise, if the grid just ahead of the current grid is free, go straight to it. Otherwise, if the grid on the left of the current grid is free, then turn left and advance to it. Otherwise, reverse the direction and proceed backward.

  S3: Repeat S2 until hit the target T or return back to the source S.

Input Format

- The first line gives the number of test cases. The first line in each test case gives M and N, i.e., the size of a maze. Then, it is followed by M rows of data. Each row has N symbols of 0, 1, S or T separated by blank spaces. The first row will be R_M, the second row will be R_{M-1}, and the k-th row will be R_{M-k+1}. Assume that R_1 is the bottom most row, as shown in the example of the previous slide. The column is numbered from left to right.

- Example

```
6
5 5
1 1 1 1 1
1 0 1 0 1
1 0 0 0 1
S 0 1 0 T
1 1 1 1 1
6 7
1 1 1 S 1 1 1
1 0 0 0 0 0 1
1 0 0 1 1 1 T
1 0 0 0 0 0 1
1 0 1 1 0 1 1
1 1 1 1 1 1 1
```

```
6 8
1 1 T 1 1 1 1 1
1 0 0 1 1 0 1 1
1 0 1 0 0 0 0 1
1 0 1 0 1 0 0 S
1 0 0 0 1 0 1 1
1 1 1 1 1 1 1 1
10 10
1 1 1 1 1 1 1 T 1 1
1 1 0 1 0 1 0 0 0 1
1 0 0 1 0 1 0 0 0 1
1 0 0 0 0 1 1 0 1 1
1 1 0 1 0 0 0 0 0 1
1 0 0 1 0 1 1 0 1 1
1 0 0 0 0 0 1 0 0 1
1 0 0 1 0 1 1 0 1 1
1 1 0 1 0 1 0 0 0 1
1 1 S 1 1 1 1 1 1 1
```

```
6 8
1 1 S 1 1 1 1 1
1 0 0 1 1 0 1 1
1 0 1 0 0 0 0 1
1 0 1 0 1 0 0 T
1 0 0 0 1 0 1 1
1 1 1 1 1 1 1 1
10 10
1 1 1 1 1 1 1 1 S 1
1 1 0 1 0 1 0 0 0 1
1 0 0 1 0 1 0 0 0 1
1 0 0 0 0 1 1 0 1 1
1 1 0 1 0 0 0 0 0 1
1 0 0 1 0 1 1 0 1 1
T 0 0 0 0 0 1 0 0 1
1 0 0 1 0 1 1 0 1 1
1 1 0 1 0 1 0 0 0 1
1 1 1 1 1 1 1 1 1 1
```

Output Format

- The output of each test case takes a line starting with a '#'. See the example below for details.

```
6
5 5
1 1 1 1 1
1 0 1 0 1
1 0 0 0 1
S 0 1 0 T
1 1 1 1 1
# Source coordinates: (2, 1).   Target coordinates: (2, 5), Distance traveled: 10
6 7
1 1 1 S 1 1 1
1 0 0 0 0 0 1
1 0 0 1 1 1 T
1 0 0 0 0 0 1
1 0 1 1 0 1 1
1 1 1 1 1 1 1
# Source coordinates: (6, 4).   Target coordinates: (-1, -1), Distance traveled: 24
6 8
1 1 T 1 1 1 1 1
1 0 0 1 1 0 1 1
1 0 1 0 0 0 0 1
1 0 1 0 1 0 0 S
1 0 0 0 1 0 1 1
1 1 1 1 1 1 1 1
# Source coordinates: (3, 8).   Target coordinates: (6, 3), Distance traveled: 16
10 10
1 1 1 1 1 1 1 T 1 1
1 1 0 1 0 1 0 0 0 1
1 0 0 1 0 1 0 0 0 1
1 0 0 0 0 1 1 0 1 1
1 1 0 1 0 0 0 0 0 1
1 0 0 1 0 1 1 0 1 1
1 0 0 0 0 0 1 0 0 1
1 0 0 1 0 1 1 0 1 1
1 1 0 1 0 1 0 0 0 1
1 1 S 1 1 1 1 1 1 1
# Source coordinates: (1, 3).   Target coordinates: (10, 8), Distance traveled: 30
6 8
1 1 S 1 1 1 1 1
1 0 0 1 1 0 1 1
1 0 1 0 0 0 0 1
1 0 1 0 1 0 0 T
1 0 0 0 1 0 1 1
1 1 1 1 1 1 1 1
# Source coordinates: (6, 3).   Target coordinates: (3, 8), Distance traveled: 16
10 10
1 1 1 1 1 1 1 1 S 1
1 1 0 1 0 1 0 0 0 1
1 0 0 1 0 1 0 0 0 1
1 0 0 0 0 1 1 0 1 1
1 1 0 1 0 0 0 0 0 1
1 0 0 1 0 1 1 0 1 1
T 0 0 0 0 0 1 0 0 1
1 0 0 1 0 1 1 0 1 1
1 1 0 1 0 1 0 0 0 1
1 1 1 1 1 1 1 1 1 1
# Source coordinates: (10, 9).   Target coordinates: (4, 1), Distance traveled: 40
```

main() Function

```
int main()
{
    int numTest;
    char maze[dim1][dim2];
    cin >> numTest;
    for(int i =0; i<numTest; i++){
        int column;
        int row;
        int numOfMove;
        int startX;
        int startY;
        int targetX;
        int targetY;
        cin >> row >> column;
        readMaze(maze, row, column, startX, startY );
        numOfMove = findPath(maze, row, column, startX, startY, targetX, targetY);
        if(targetX == -1 && targetY == -1)
        cout <<  "# Source coordinates: (" << row-startX << ", " << startY+1 <<  ").   Target coordinates: ("
        << targetX << ", " << targetY<< "), Distance traveled: " << numOfMove <<endl;
        else
            cout <<  "# Source coordinates: (" << row-startX << ", " << startY+1 <<  ").   Target coordinates: ("
            << row-targetX+1 << ", " << targetY<< "), Distance traveled: " << numOfMove <<endl;
    }
    return 0;
}
```

Requirements

- **The main() function should not be modified.**
- **Need to implement the following two functions.**

```
void readMaze(char [][dim2], int numRow, int numColumn, int &startX, int &startY);
int findPath(char [][dim2], int numRow, int numColumn, int startX, int startY, int &targetX, int &targetY);
```