Case study:

1(a)

My earlier solution was to this particular case only.

0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
0	0	0	0	0	1	1	1	1	1	1	1	1	2	2
0	0	0	0	1	1	1	1	1	1	1	1	2	2	2
0	0	0	0	1	1	1	1	1	1	1	2	2	2	2
0	0	0	1	1	1	1	1	1	1	2	2	2	2	2
0	0	1	1	1	1	1	1	1	2	2	2	2	2	2
1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
1	1	1	1	1	1	1	1	2	2	2	2	2	2	2

The below three cases are an alternatives of the above case.

1(b)

2	2	2	2	2	2	2	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	1	1	1	1	1	1	1	1
2	2	2	2	2	1	1	1	1	1	1	1	1	0	0
2	2	2	2	1	1	1	1	1	1	1	1	0	0	0
2	2	2	2	1	1	1	1	1	1	1	0	0	0	0
2	2	2	1	1	1	1	1	1	1	0	0	0	0	0
2	2	1	1	1	1	1	1	1	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0

1(c)

1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
2	1	1	1	1	1	1	1	1	1	0	0	0	0	0
2	2	2	1	1	1	1	1	1	1	1	0	0	0	0
2	2	2	2	1	1	1	1	1	1	1	1	0	0	0
2	2	2	2	1	1	1	1	1	1	1	1	1	0	0
2	2	2	2	1	1	1	1	1	1	1	1	1	1	0
2	2	2	2	2	1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	1	1	1	1	1	1	1	1	1

1(d)

1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
0	1	1	1	1	1	1	1	1	1	2	2	2	2	2
0	0	0	1	1	1	1	1	1	1	1	2	2	2	2
0	0	0	0	1	1	1	1	1	1	1	1	2	2	2
0	0	0	0	1	1	1	1	1	1	1	1	1	2	2
0	0	0	0	1	1	1	1	1	1	1	1	1	1	2
0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	1	1	1	1	1	1	1	1	1

In the above cases there are some arrangements which are double counted like …

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2

and

0	0	0	1	1	1	2	2	2	2
0	0	0	1	1	1	2	2	2	2
0	0	0	1	1	1	2	2	2	2
0	0	0	1	1	1	2	2	2	2
0	0	0	1	1	1	2	2	2	2
0	0	0	1	1	1	2	2	2	2
0	0	0	1	1	1	2	2	2	2
0	0	0	1	1	1	2	2	2	2
0	0	0	1	1	1	2	2	2	2
0	0	0	1	1	1	2	2	2	2

So a total of 2*(C(M-1,2) + C(N-1,2)) is to be subtracted.

2(a)

Draw a vertical line and a horizantal line which divides the rectangle into four rectangles. Now consider a dual path from bottom left to top right corner of the top left rectangle and a dual path from bottom left to top right corner of the bottom right rectangle. Put 1's between the paths and 0's and 2's as shown in the figure.

0	0	0	1	1	2	2	2	2	2	2	2	2	2	2
0	0	1	1	2	2	2	2	2	2	2	2	2	2	2
0	1	1	1	2	2	2	2	2	2	2	2	2	2	2
1	1	1	2	2	2	2	2	2	2	2	2	2	2	2
1	1	2	2	2	2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2	2	2	2	1	1
2	2	2	2	2	2	2	2	2	2	2	2	1	1	1
2	2	2	2	2	2	2	2	2	2	1	1	1	0	0
2	2	2	2	2	2	2	2	1	1	1	0	0	0	0
2	2	2	2	2	2	2	2	1	0	0	0	0	0	0

2(b)

Similar to the above but 0's and 2's interchanged.

2	2	2	1	1	0	0	0	0	0	0	0	0	0	0
2	2	1	1	0	0	0	0	0	0	0	0	0	0	0
2	1	1	1	0	0	0	0	0	0	0	0	0	0	0
1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
0	0	0	0	0	0	0	0	0	0	1	1	1	2	2
0	0	0	0	0	0	0	0	1	1	1	2	2	2	2
0	0	0	0	0	0	0	0	1	2	2	2	2	2	2

2(c)

Draw a vertical line and a horizantal line which divides the rectangle into four rectangles. Now consider a dual path from bottom right to top left corner of the top right rectangle and a dual path from bottom right to top left corner of the bottom left rectangle. Put 1's between the paths and 0's and 2's as shown in the figure.

2	2	2	2	2	2	2	2	2	2	1	1	0	0	0
2	2	2	2	2	2	2	2	2	2	1	1	1	0	0
2	2	2	2	2	2	2	2	2	2	2	1	1	1	0
2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1	1	2	2	2	2	2	2	2	2	2	2	2	2	2
0	1	1	1	2	2	2	2	2	2	2	2	2	2	2
0	0	1	1	1	1	2	2	2	2	2	2	2	2	2
0	0	0	1	1	1	2	2	2	2	2	2	2	2	2

2(d)

Same as the above with 2's replaced by 0's and 0's replaced by 2's

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3(a)

Consider a rectangle at the top left portion. Take a path from the bottom right corner of this rectangle to bottom right corner of original rectangle. Fill the numbers as shown in the figure. Corresponding to one arrangement in the figure shown below there are three more actual arrangements (i.e ; rectangle can be taken at any of the four corners and a similar arrangement can be done)

2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

3(b)

Same as the above with 1's replaced by 0's and 0's replaced by 1's.

3(c)

0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2	2	2	1	1	1
2	2	2	2	2	2	2	2	2	2	2	2	2	2	1

3(d)

Same as the above with 2's replaced 1's and 1's replaced by 2's

(4)

Draw a vertical line and a horizantal line which divides the rectangle into four rectangles. Take paths from bottom left to top right, top left to bottom right, top right to bottom left and bottom right to top left of the four rectangles taken in clockwise order starting from top left rectangle and fill the numbers as shown in the figure. We need to do a careful counting of the total number of possibilities as we might count the same arrangement twice.

2	2	2	2	2	1	1	1	1	0	0	0	0	0	0
2	2	2	2	1	1	1	1	1	1	0	0	0	0	0
2	2	2	1	1	1	1	1	1	1	1	0	0	0	0
2	2	1	1	1	1	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0	0	1	1	1	1	1	1	1	1	1	1	2	2	2
0	0	0	1	1	1	1	1	1	1	1	2	2	2	2
0	0	0	0	1	1	1	1	1	1	2	2	2	2	2
0	0	0	0	0	1	1	1	1	1	2	2	2	2	2