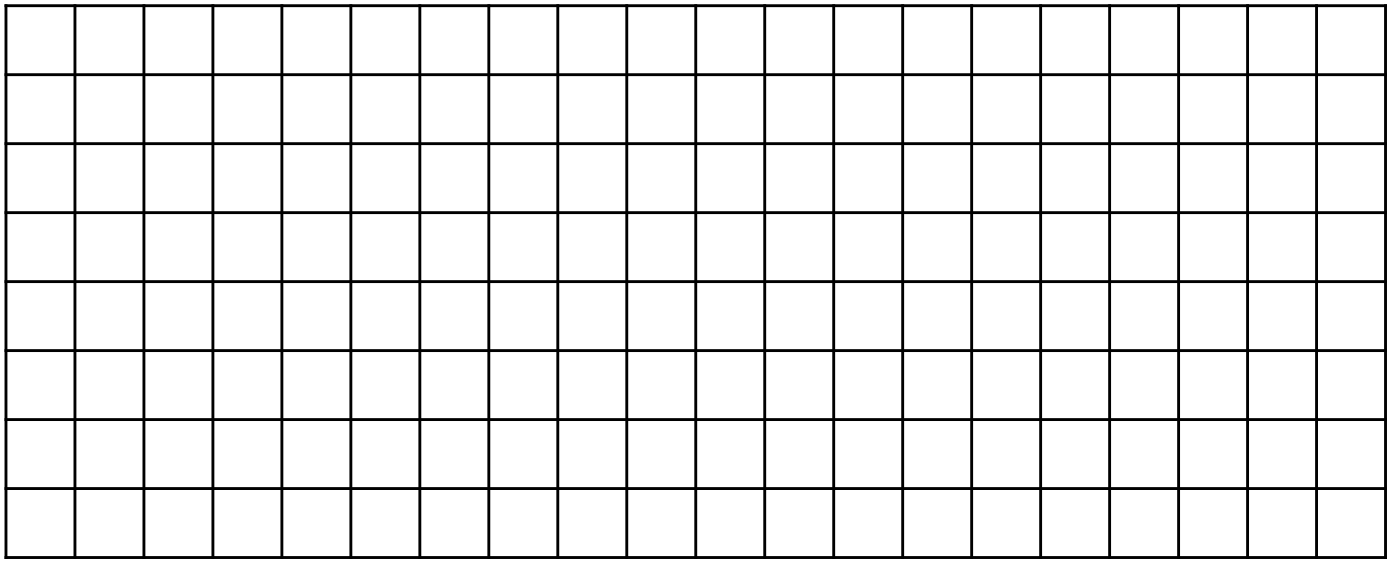
Wave-Front Planner

Alfredo Weitzenfeld

Wave-Front Planner

- World space representation as grids.
- Distance is reduced to discrete uniform steps.
- Direction is limited from one adjacent cell to another.
- Simplest solution to local minima problem.

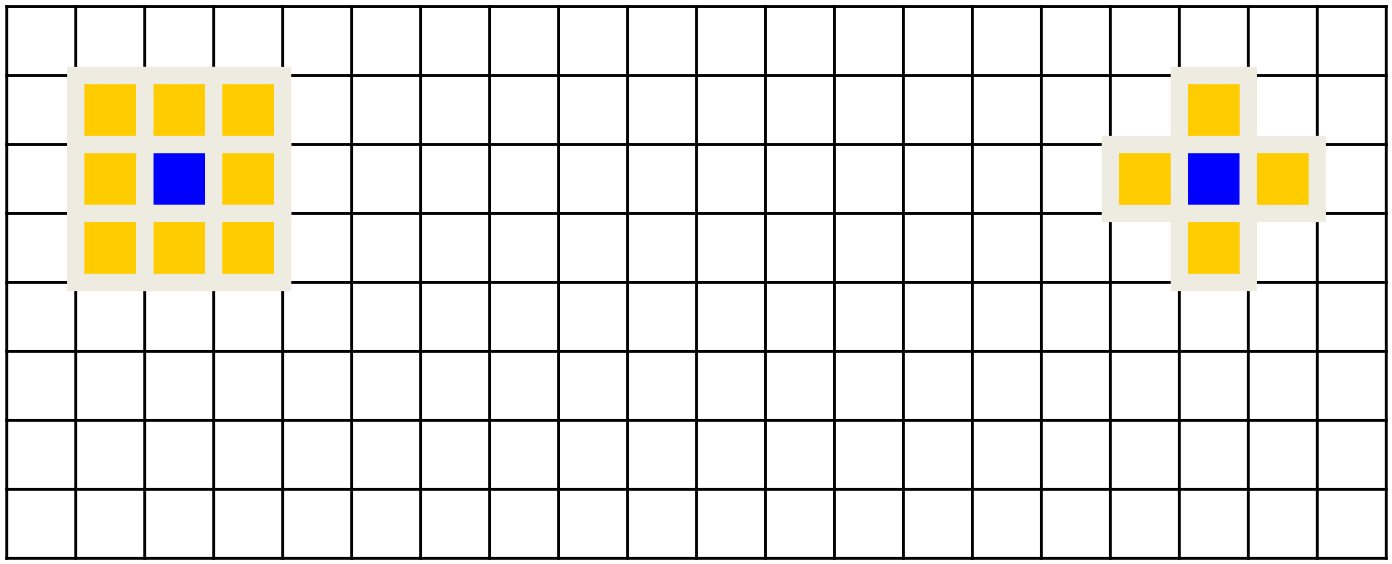


Wave-Front Planner

- Number the squares starting at the start in either 4 or 8 point connectivity starting at the goal, increasing till you reach the start.
- The path is defined by any uninterrupted sequence of decreasing numbers that lead to the goal.
- The planner determines a path via gradient descent on the grid from start to goal.
- The major drawback of this method is that the planner has to search the entire space for a path.

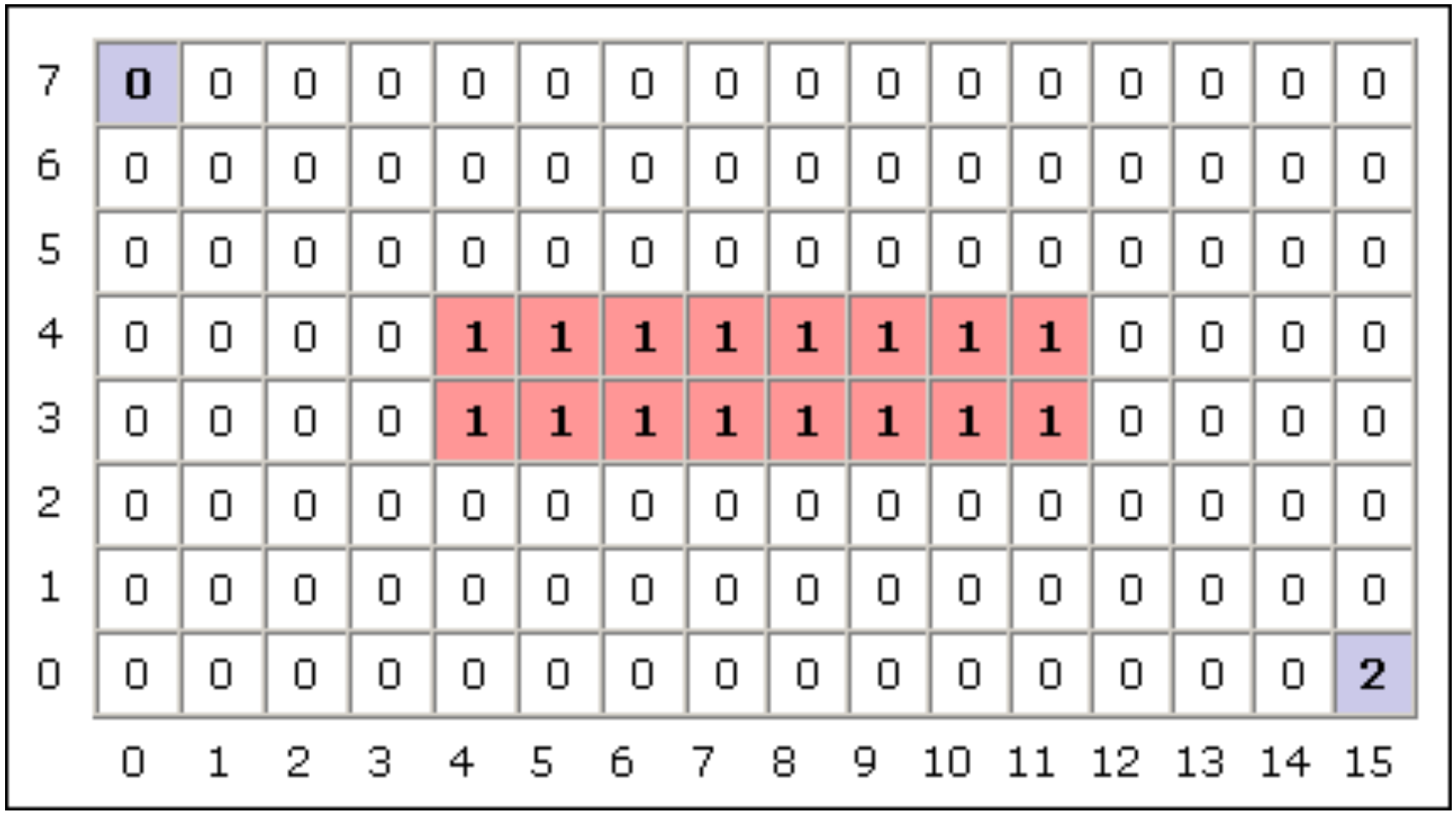
Wave-Front Planner

- 8-Point Connectivity
- 4-Point Connectivity



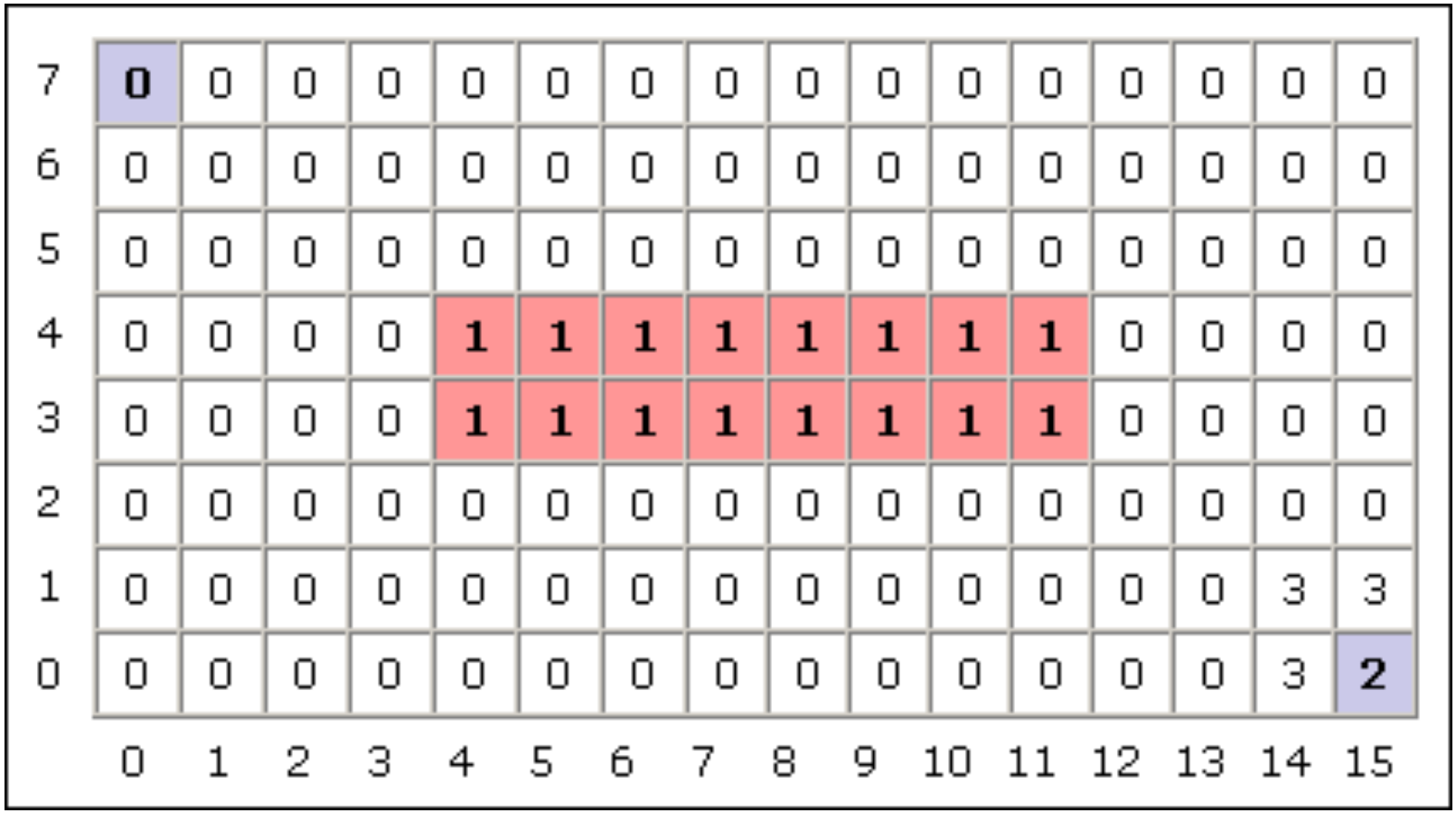
Wave-Front Planner: Setup

- Initially all free grid elements are 0, obstacles are set to 1. The planner knows the location of start and goal. Goal is labeled with 2.



Wave-Front Planner: Step 1

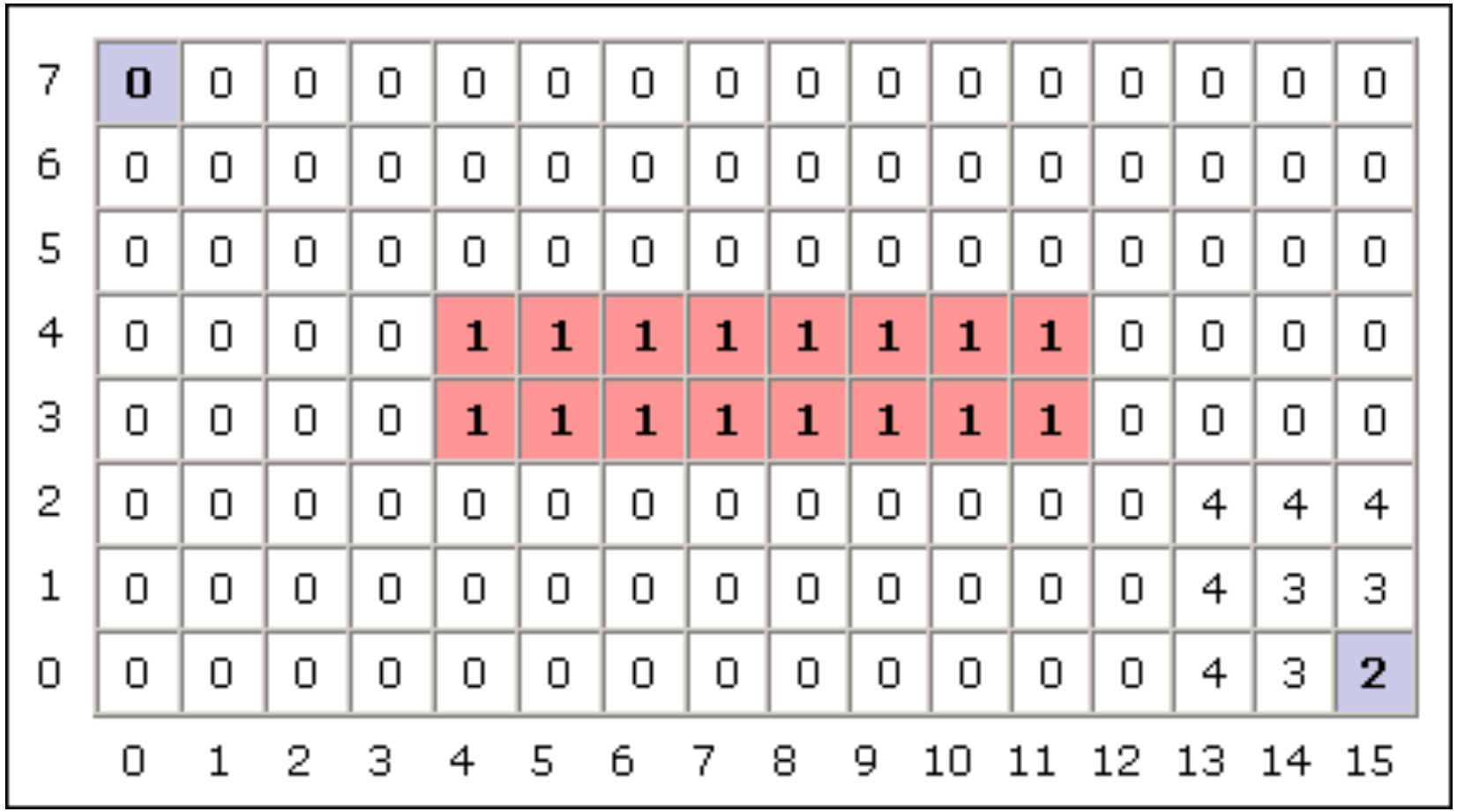
- Starting with the goal, set all adjacent cells with "0" to the current cell + 1 (e.g. using 8-Point Connectivity)



	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
7	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	0	0	0	0
3	0	0	0	0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	**2**

Wave-Front Planner: Step 2

- Repeat with the modified cells until no 0's are adjacent to cells with values >= 2
- 0's will only remain when regions are unreachable



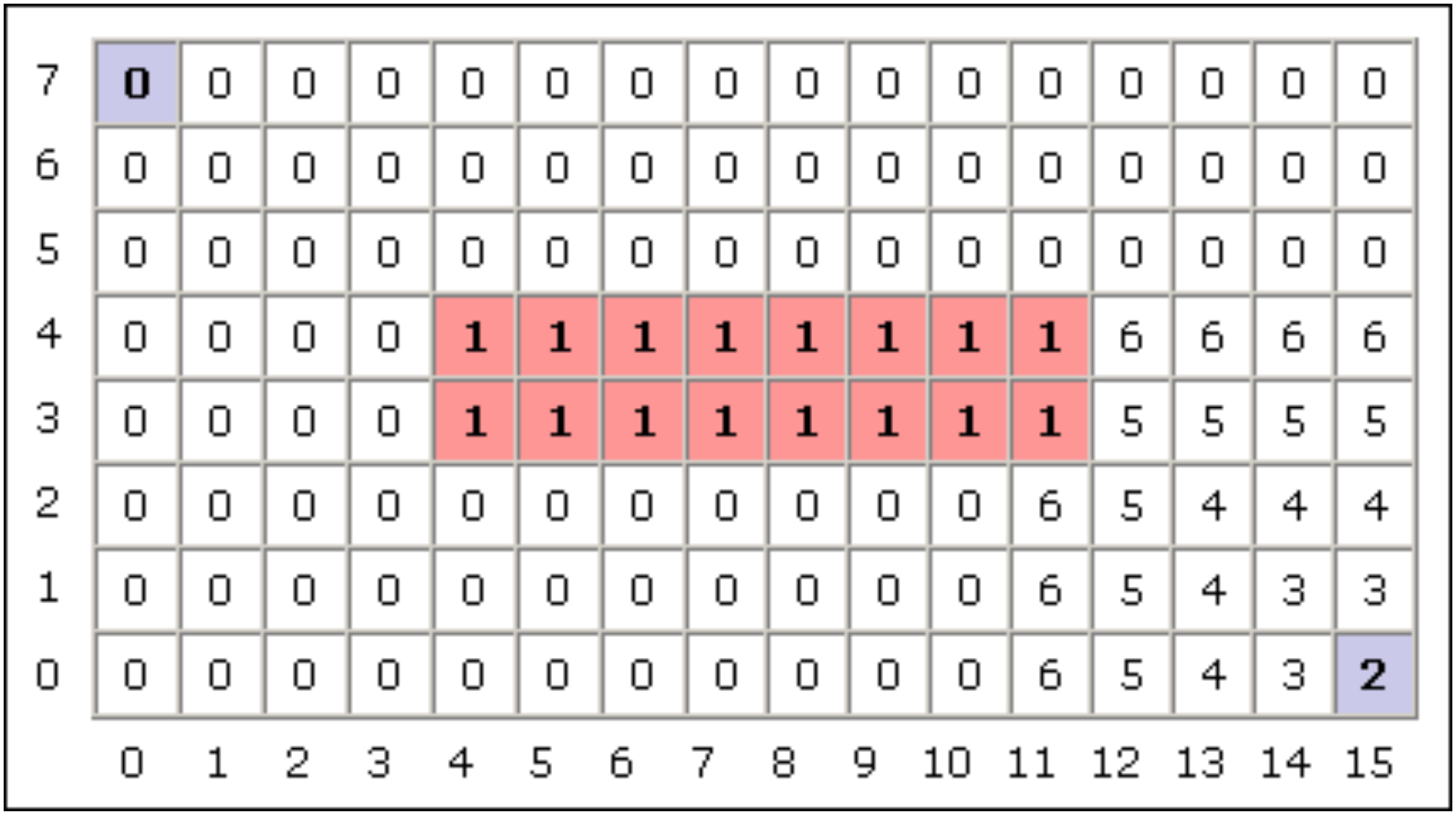
Wave-Front Planner: Step 3

- Repeat again...

7	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	0	0	0	0
3	0	0	0	0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	5	5	5	5
2	0	0	0	0	0	0	0	0	0	0	0	0	5	4	4	4
1	0	0	0	0	0	0	0	0	0	0	0	0	5	4	3	3
0	0	0	0	0	0	0	0	0	0	0	0	0	5	4	3	**2**
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Wave-Front Planner: Step 4

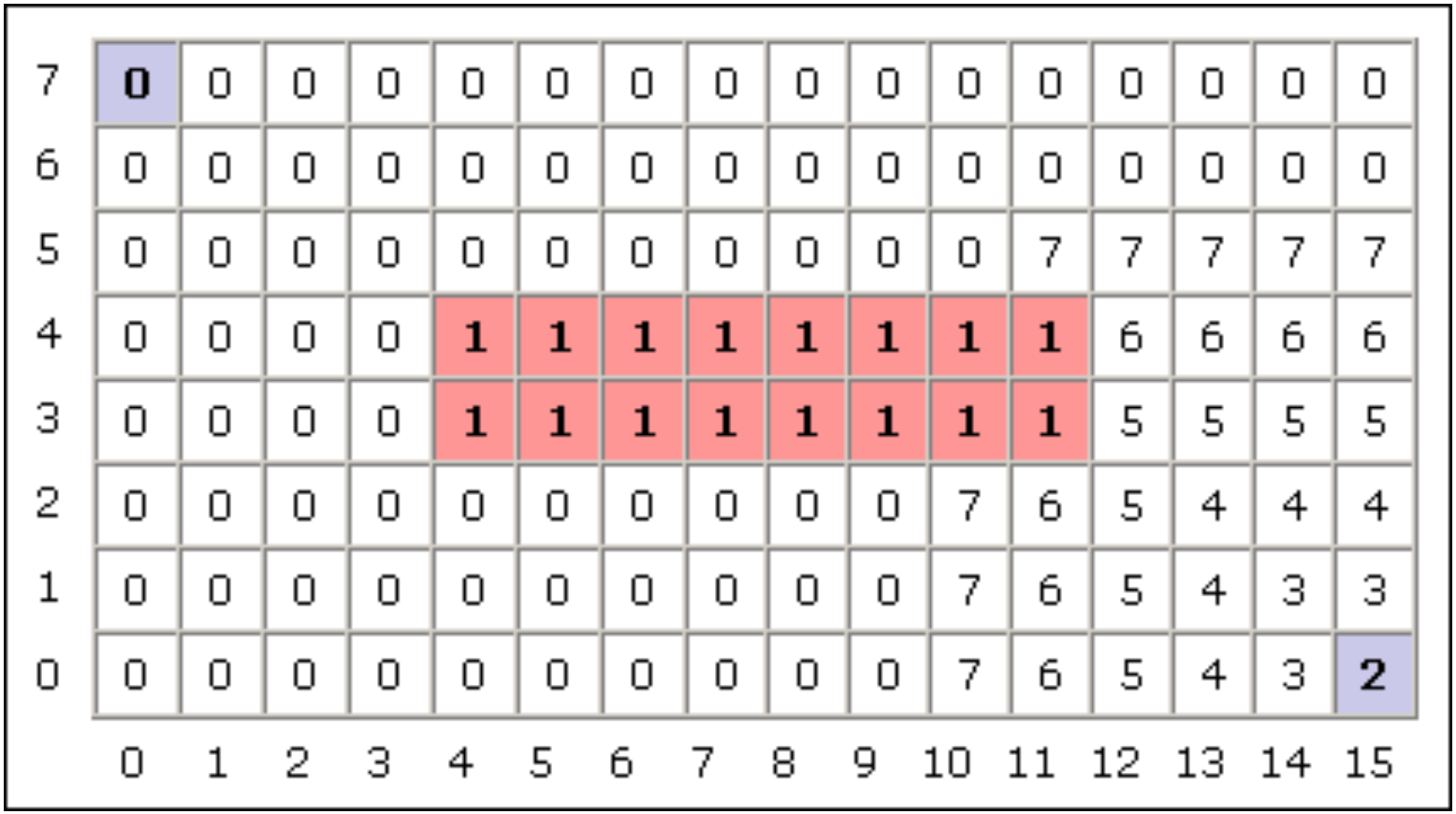
- And again...



7	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	6	6	6	6
3	0	0	0	0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	5	5	5	5
2	0	0	0	0	0	0	0	0	0	0	0	6	5	4	4	4
1	0	0	0	0	0	0	0	0	0	0	0	6	5	4	3	3
0	0	0	0	0	0	0	0	0	0	0	0	6	5	4	3	**2**
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Wave-Front Planner: Step 5

- And again until...



Wave-Front Planner: Final Step

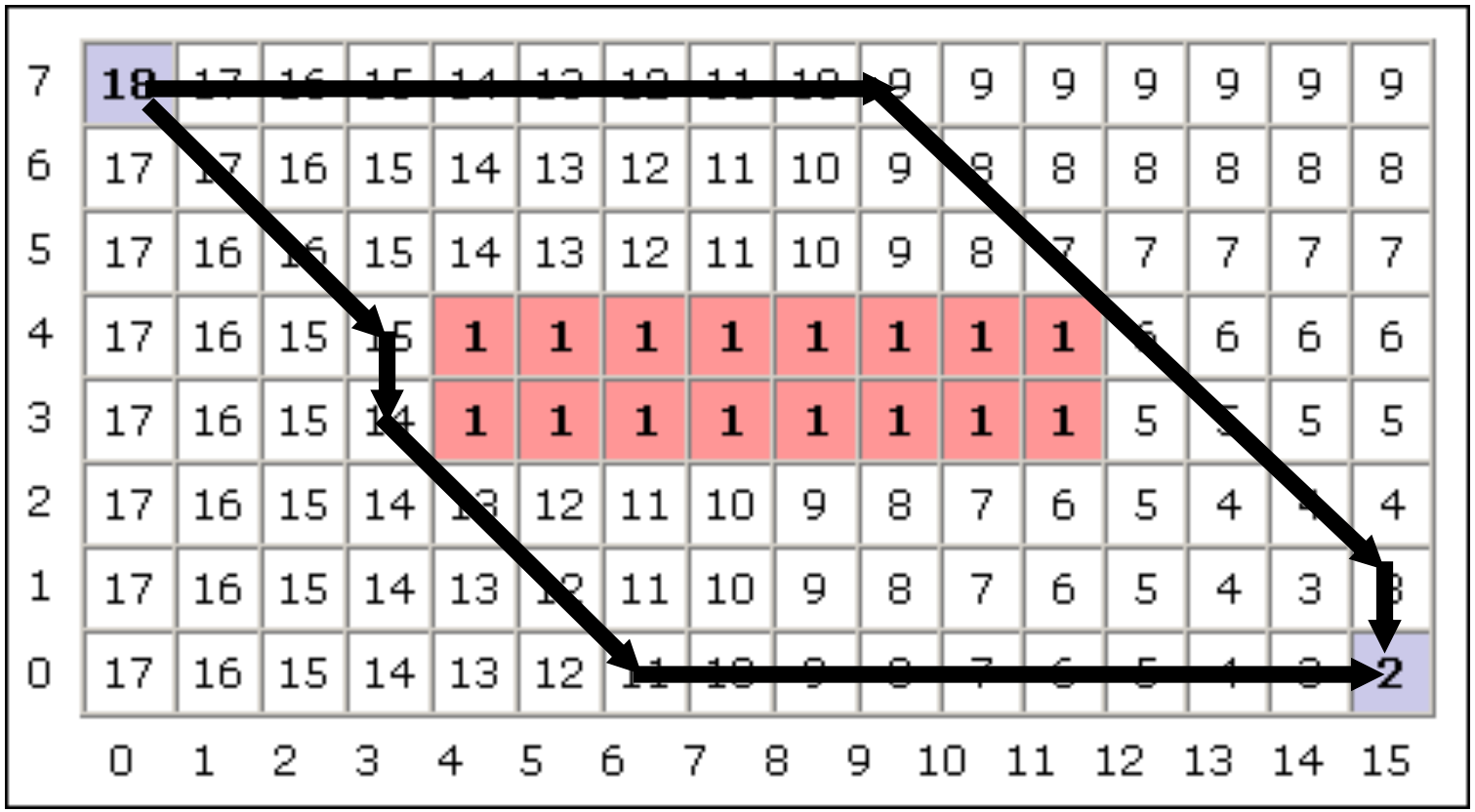
- Until you're done

7	**18**	17	16	15	14	13	12	11	10	9	9	9	9	9	9	9
6	17	17	16	15	14	13	12	11	10	9	8	8	8	8	8	8
5	17	16	16	15	14	13	12	11	10	9	8	7	7	7	7	7
4	17	16	15	15	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	6	6	6	6
3	17	16	15	14	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	5	5	5	5
2	17	16	15	14	13	12	11	10	9	8	7	6	5	4	4	4
1	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	3
0	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	**2**
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Wave-Front Planner: Path

- The shortest path is determined by gradient descent by initiating at the start and then moving a cell are a time towards a cell with a lower number.
- The numbers generated by the Wave-Front planner are roughly proportional to their Manhattan distance from the goal.

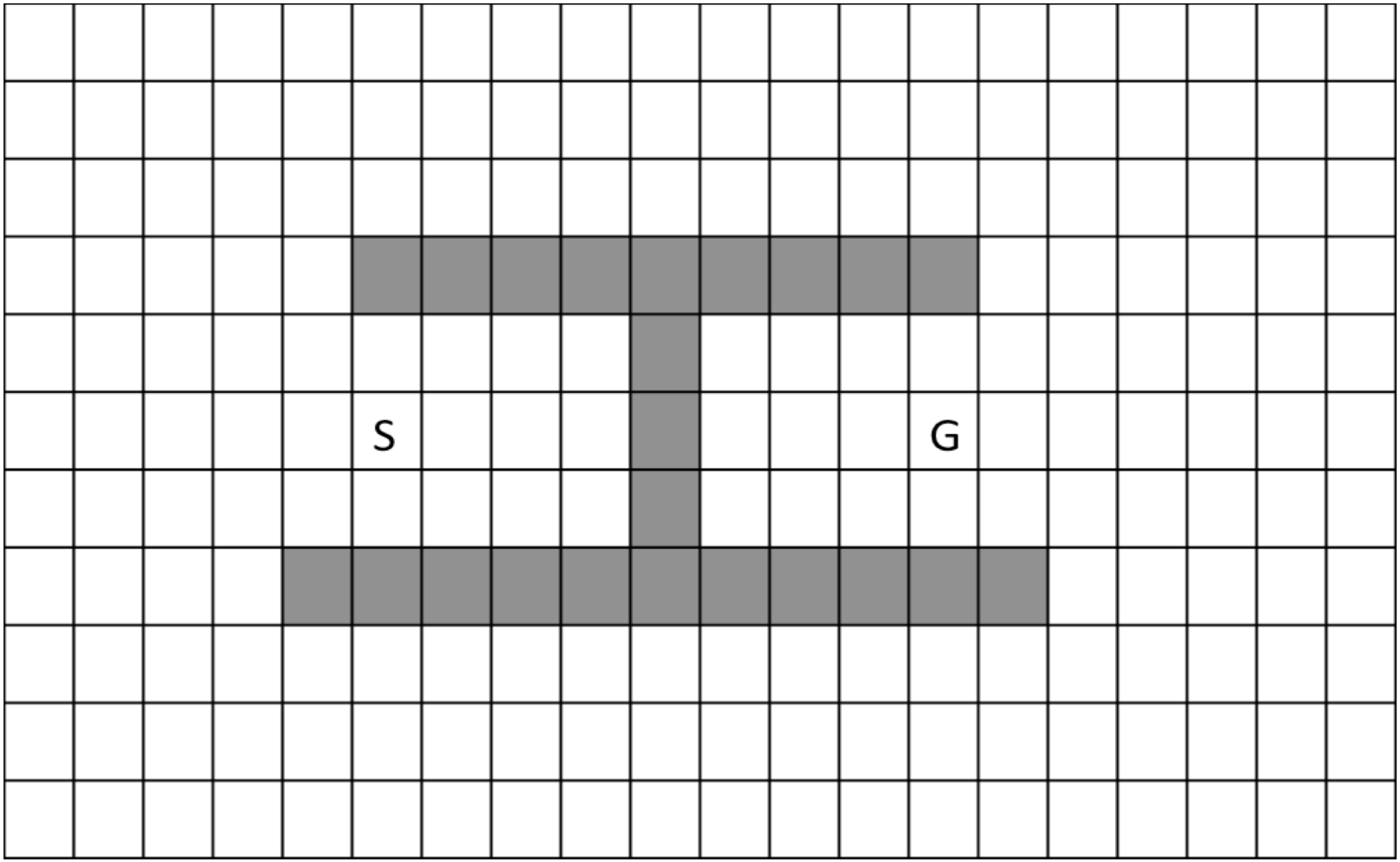
Two possible shortest paths shown



Wave-Front Planner

Spring 2017

Apply the WaveFront Planner algorithm to the scene below using 4-point connectivity where darker elements correspond to obstacles, “S” represents the start location, and “G” represents the goal location. Show the final navigation path between start and goal.



Wave-Front Planner

Spring 2017

Apply the WaveFront Planner algorithm to the scene below using 4-point connectivity where darker elements correspond to obstacles, “S” represents the start location, and “G” represents the goal location. Show the final navigation path between start and goal.

22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	9	10	11	12	13
21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	8	9	10	11	12
20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	7	8	9	10	11
21	20	19	18	17	1	1	1	1	1	1	1	1	1	5	6	7	8	9	10
22	21	20	19	18	19	20	21	22	1	6	5	4	3	4	5	6	7	8	9
23	22	21	20	19	S	21	22	23	1	5	4	3	G	3	4	5	6	7	8
24	23	22	21	20	21	22	23	24	1	6	5	4	3	4	5	6	7	8	9
23	22	21	20	1	1	1	1	1	1	1	1	1	1	1	6	7	8	9	10
22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	8	9	10	11
23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	9	10	11	12
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	10	11	12	13

Wave-Front Planner

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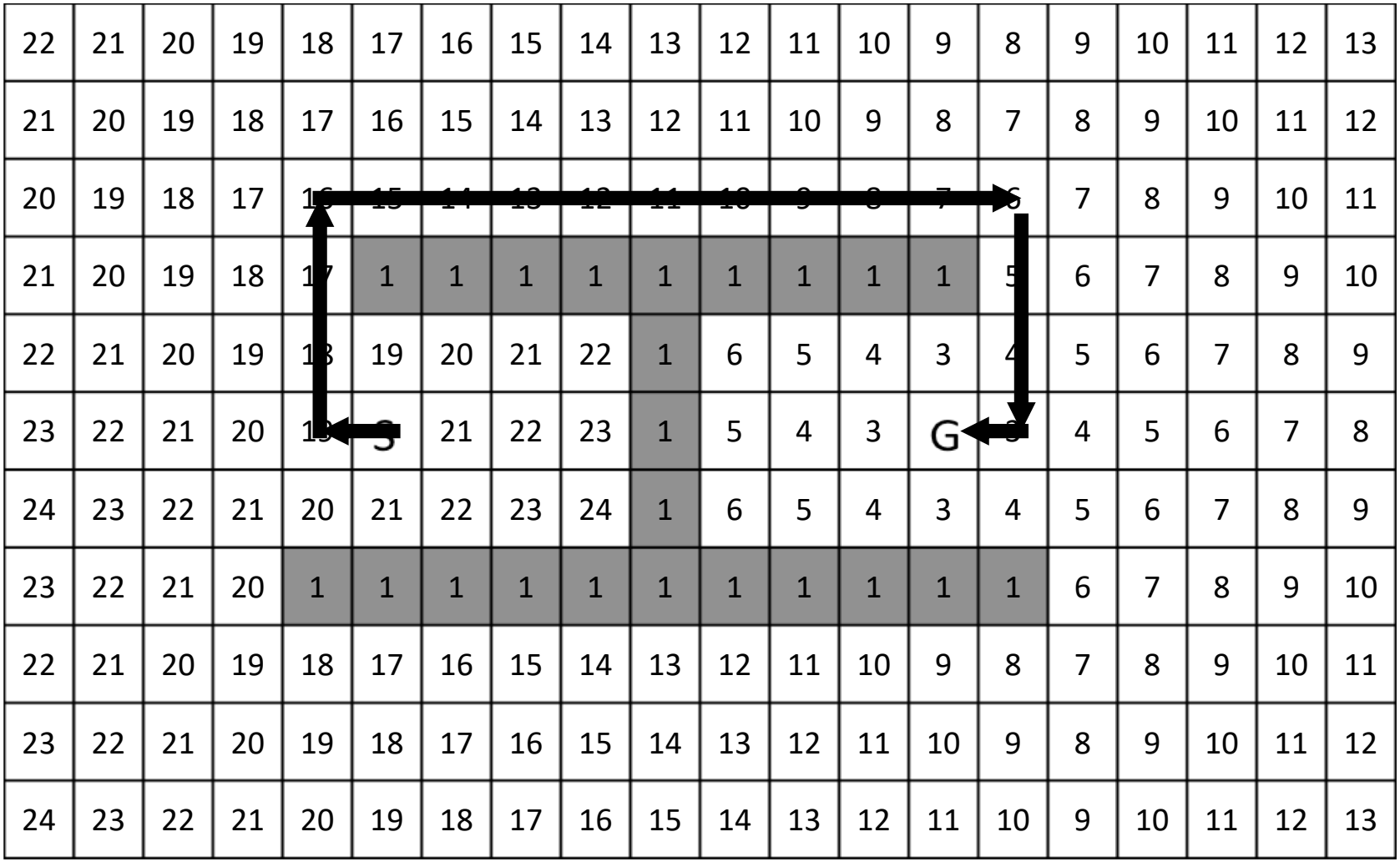
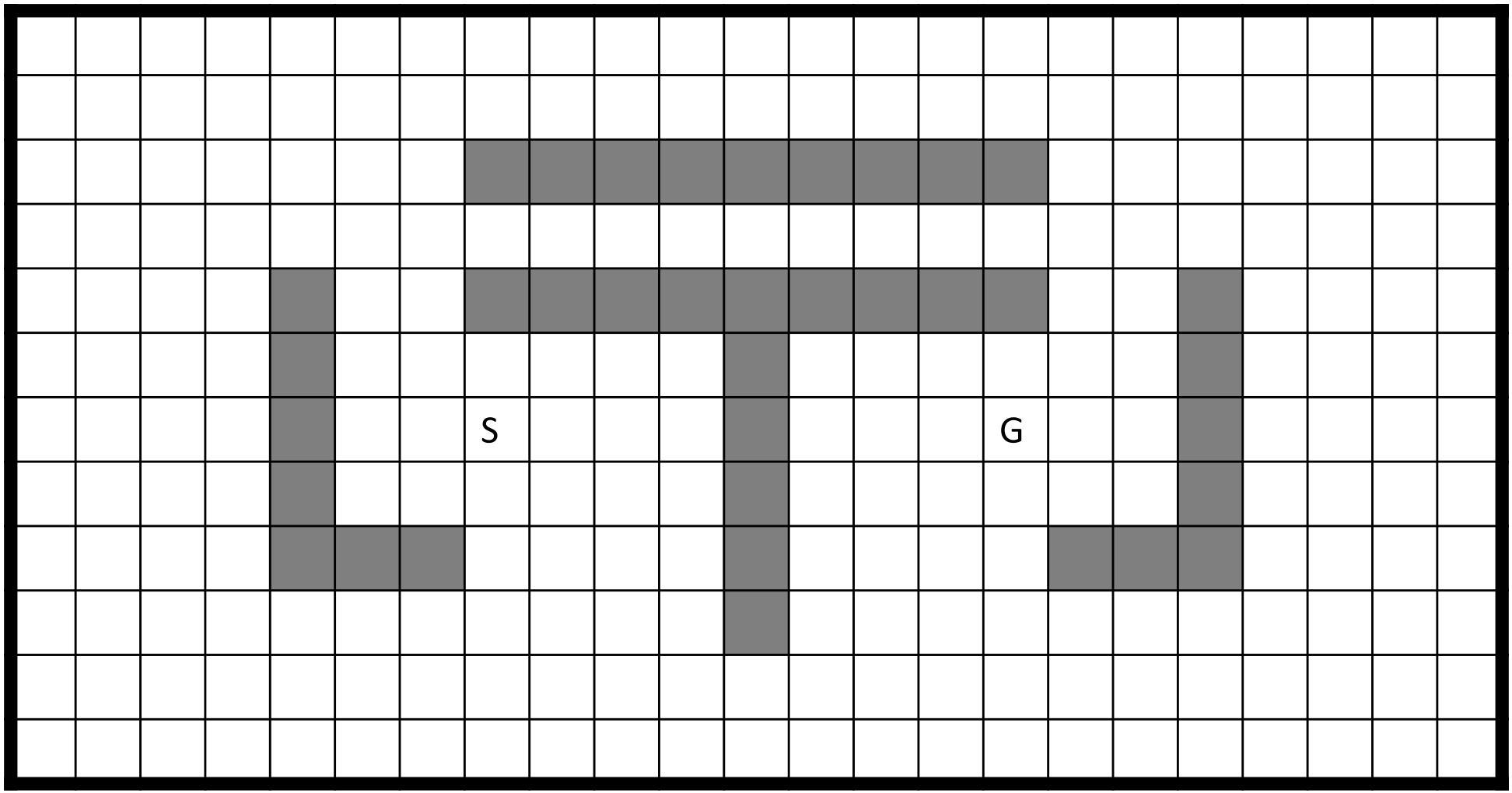


Wave-Front Planner

Spring 2017

Apply the WaveFront Planner algorithm to the scene below using 4-point connectivity where darker elements correspond to obstacles, “S” represents the start location, and “G” represents the goal location. Show the final navigation path between start and goal. Note the outside boundaries on the outside of the scene that may also be considered as obstacles.



Wave-Front Planner

Spring 2017

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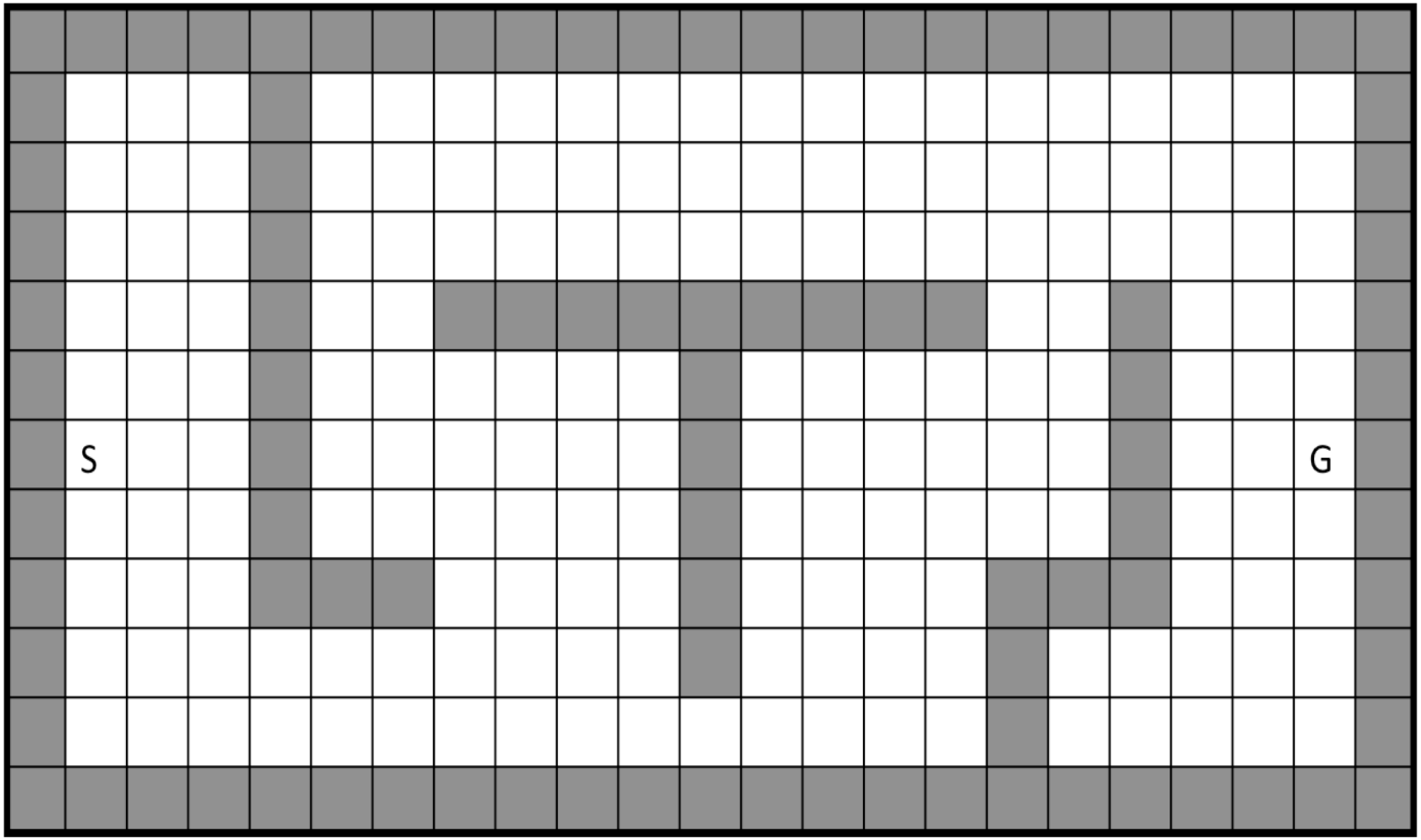
						17	16	15	14	13	12	11	10	9	8	7	8	9	10	11	12	
																6	7	8	9	10	11	
						15	14	13	12	11	10	9	8	7	6	5	6	7	8	9	10	
						16										4	5		9			
						17						5	4	3	2	3	4		10			
						18	S					4	3	2	G	2	3		11			
							16					5	4	3	2	3	4		12			
							15					6			3				13			
							14					7			4				14			
							13	12	11	10	9	8	7	6	5		17	16	15			

Wave-Front Planner

Fall 2017

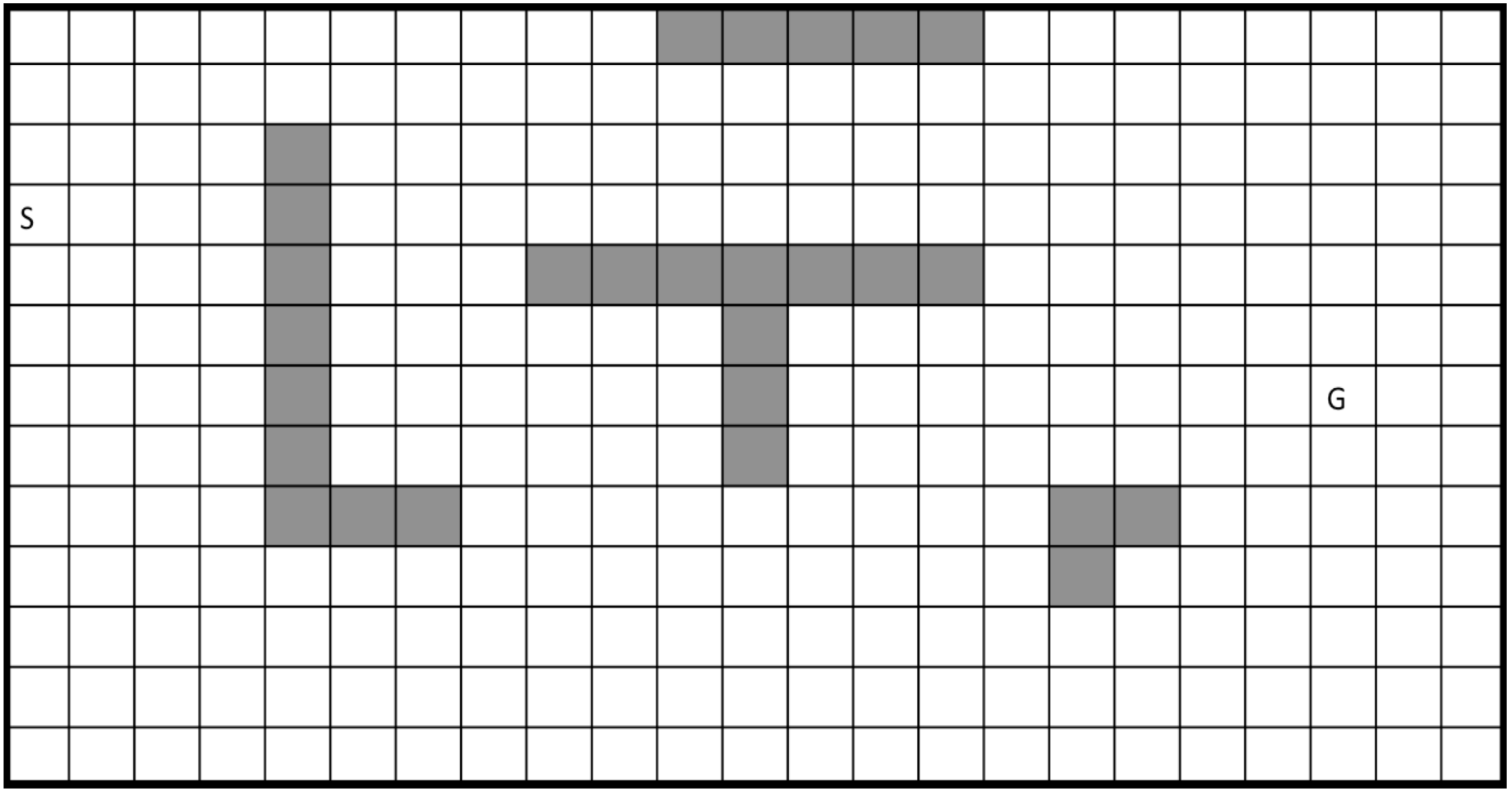
Apply the WaveFront Planner algorithm to the scene below using 4-point connectivity where darker elements correspond to obstacles, “S” represents the start location, and “G” represents the goal location. Show the final navigation path between start and goal.



Wave-Front Planner

Spring 2018

Apply the WaveFront Planner algorithm to the scene below using 8-point connectivity where darker elements correspond to obstacles, “S” represents the start location, and “G” represents the goal location. Show the final navigation path between start and goal. Note the outside boundaries on the outside of the scene that may also be considered as obstacles.



Wave-Front Planner

Spring 2018

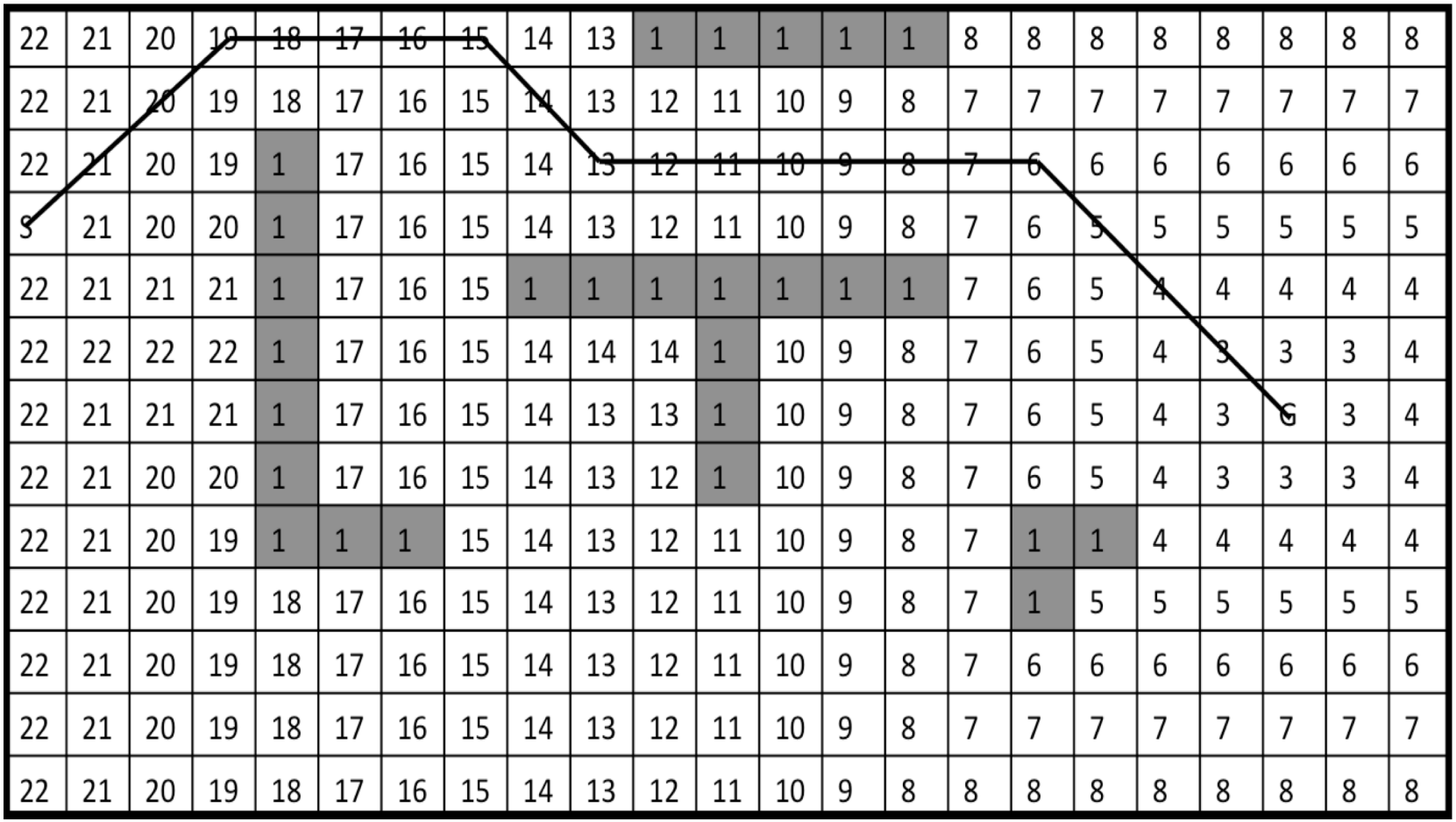
Apply the WaveFront Planner algorithm to the scene below using 8-point connectivity where darker elements correspond to obstacles, “S” represents the start location, and “G” represents the goal location. Show the final navigation path between start and goal. Note the outside boundaries on the outside of the scene that may also be considered as obstacles.

22	21	20	19	18	17	16	15	14	13	1	1	1	1	1	8	8	8	8	8	8	8	8
22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	7	7	7	7	7	7	7
22	21	20	19	1	17	16	15	14	13	12	11	10	9	8	7	6	6	6	6	6	6	6
S	21	20	20	1	17	16	15	14	13	12	11	10	9	8	7	6	5	5	5	5	5	5
22	21	21	21	1	17	16	15	1	1	1	1	1	1	1	7	6	5	4	4	4	4	4
22	22	22	22	1	17	16	15	14	14	14	1	10	9	8	7	6	5	4	3	3	3	4
22	21	21	21	1	17	16	15	14	13	13	1	10	9	8	7	6	5	4	3	G	3	4
22	21	20	20	1	17	16	15	14	13	12	1	10	9	8	7	6	5	4	3	3	3	4
22	21	20	19	1	1	1	15	14	13	12	11	10	9	8	7	1	1	4	4	4	4	4
22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	1	5	5	5	5	5	5
22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	6	6	6	6	6	6
22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	7	7	7	7	7	7	7
22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	8	8	8	8	8	8	8	8

Wave-Front Planner

Spring 2018

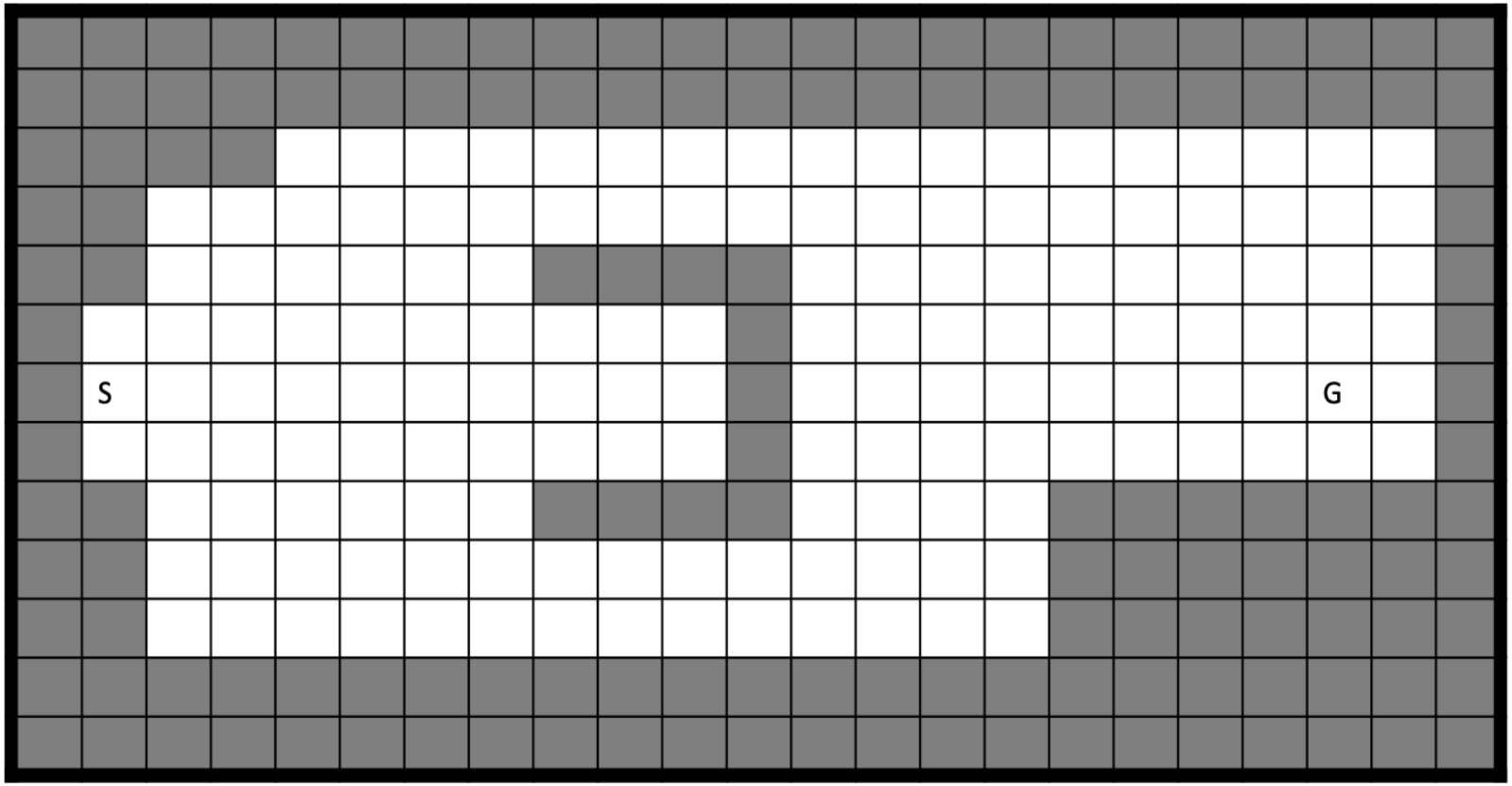
Apply the WaveFront Planner algorithm to the scene below using 8-point connectivity where darker elements correspond to obstacles, “S” represents the start location, and “G” represents the goal location. Show the final navigation path between start and goal. Note the outside boundaries on the outside of the scene that may also be considered as obstacles.



WaveFront Planner

Fall 2018

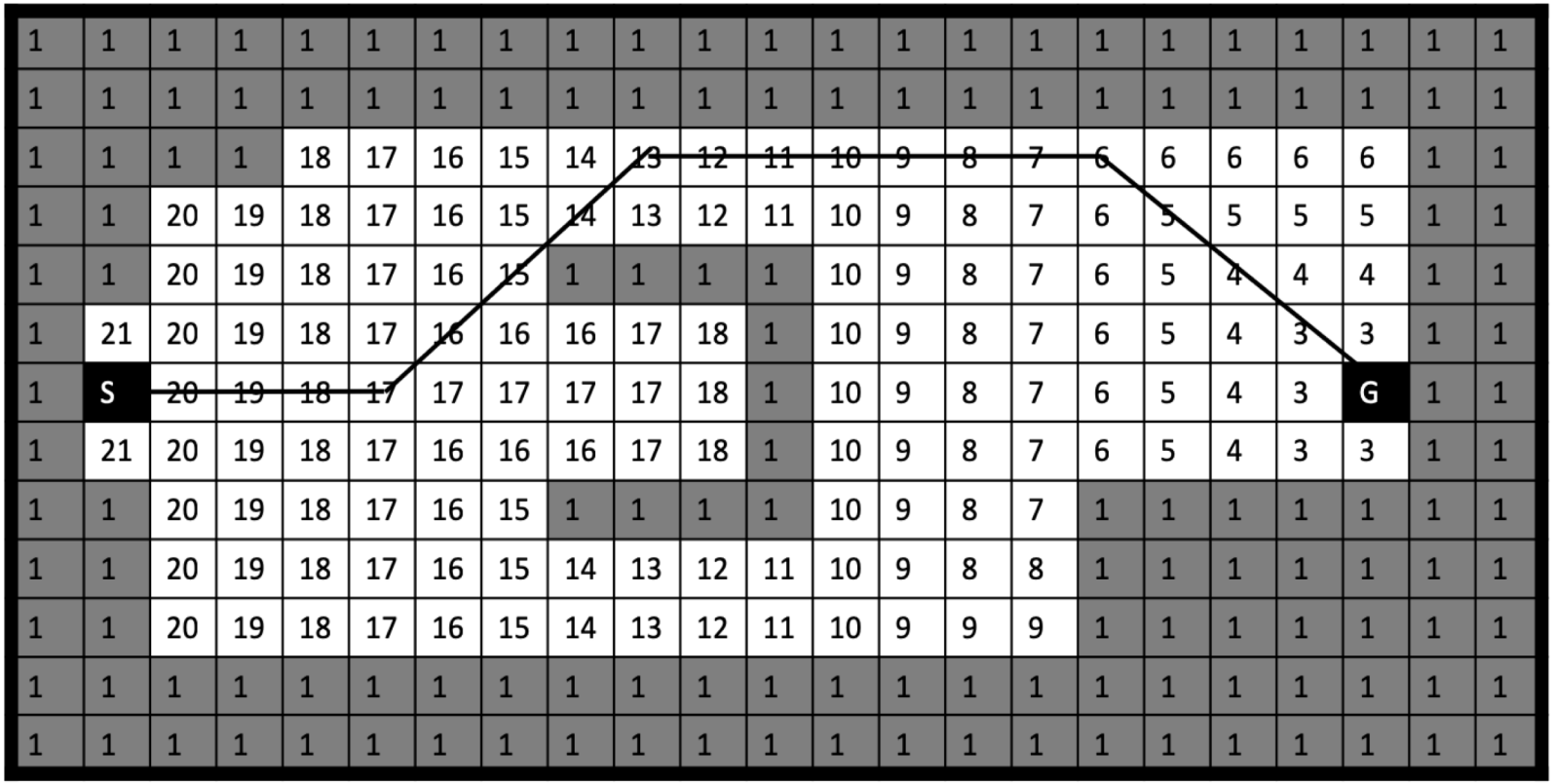
Apply the WaveFront Planner algorithm to number ALL cells in the diagram, and then show the shortest path between “S” and “G”.



WaveFront Planner

Fall 2018

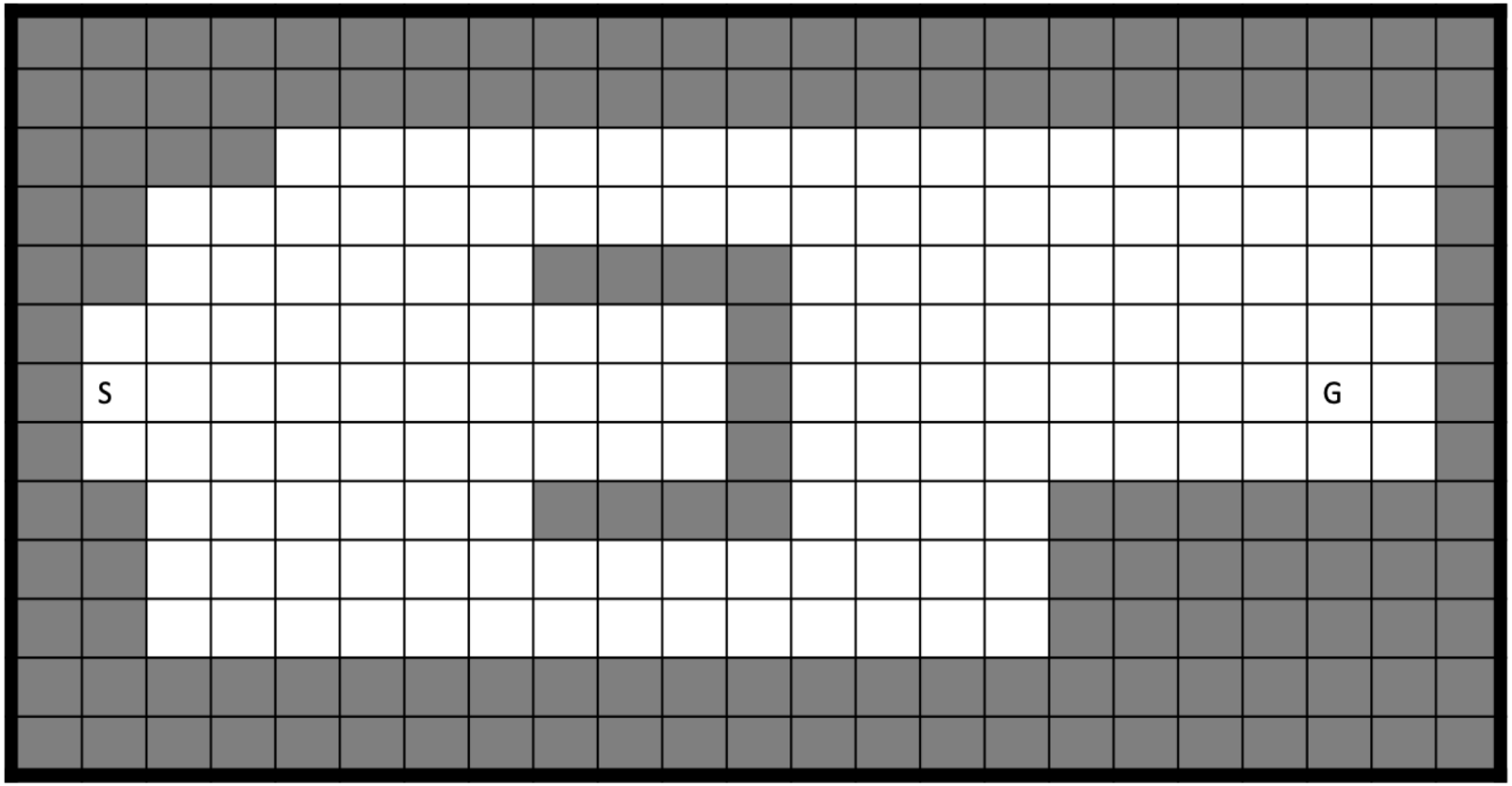
Apply the WaveFront Planner algorithm to number ALL cells in the diagram, and then show the shortest path between “S” and “G”.



WaveFront Planner

Fall 2018

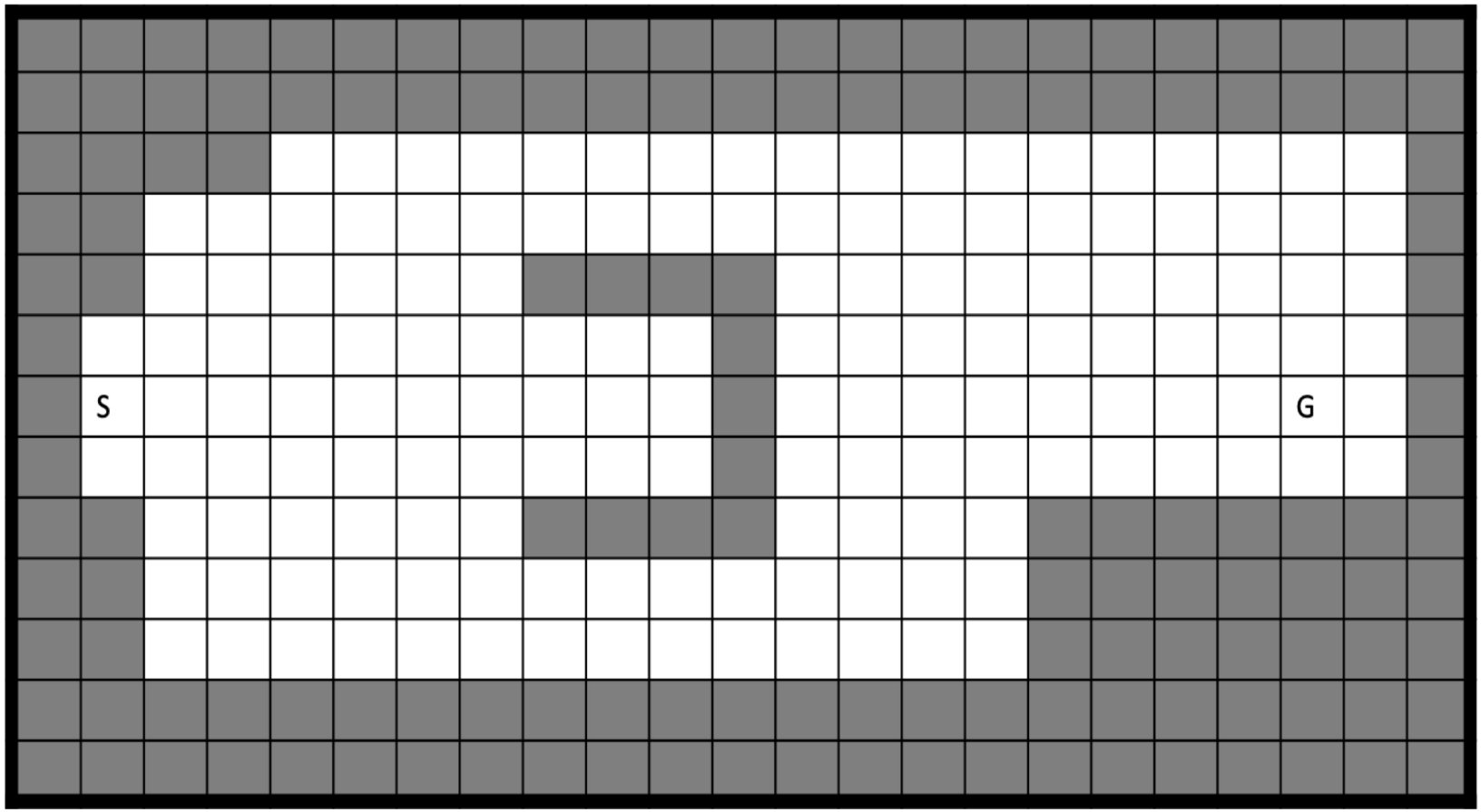
If it exists, find a path from “S” that will not reach “G”, and then highlight it in the diagram (there is no need to number all boxes again, just the necessary ones to justify your answer)



WaveFront Planner

Fall 2018

For the wavefront planner algorithm, all paths starting at S will lead to G.



WaveFront Planner

Fall 2018

Would you need to renumber the map if you choose a different starting location “S” while keeping the same goal “G”?

Would you need to renumber the map if you choose a different goal location “G”, while keeping the same start “S”?

WaveFront Planner

Fall 2018

Would you need to renumber the map if you choose a different starting location “S” while keeping the same goal “G”?

- There is no need to recalculate the map numbering when choosing a different starting point “S” with same goal “G”.

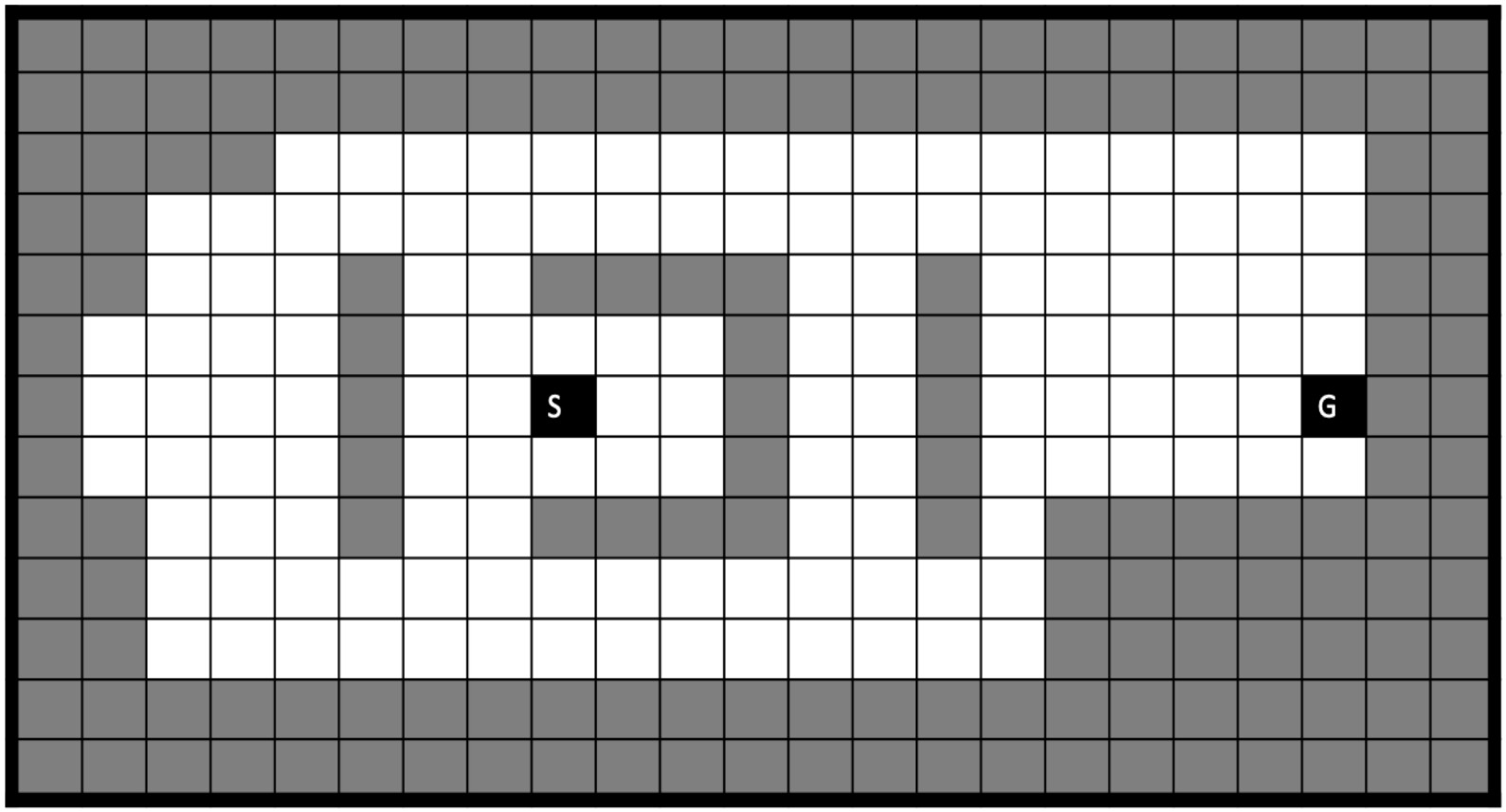
Would you need to renumber the map if you choose a different goal location “G”, while keeping the same start “S”?

- You will need to renumber the map when choosing a different “G” goal location, independent on the starting “S” location.

WaveFront Planner

Spring 2019

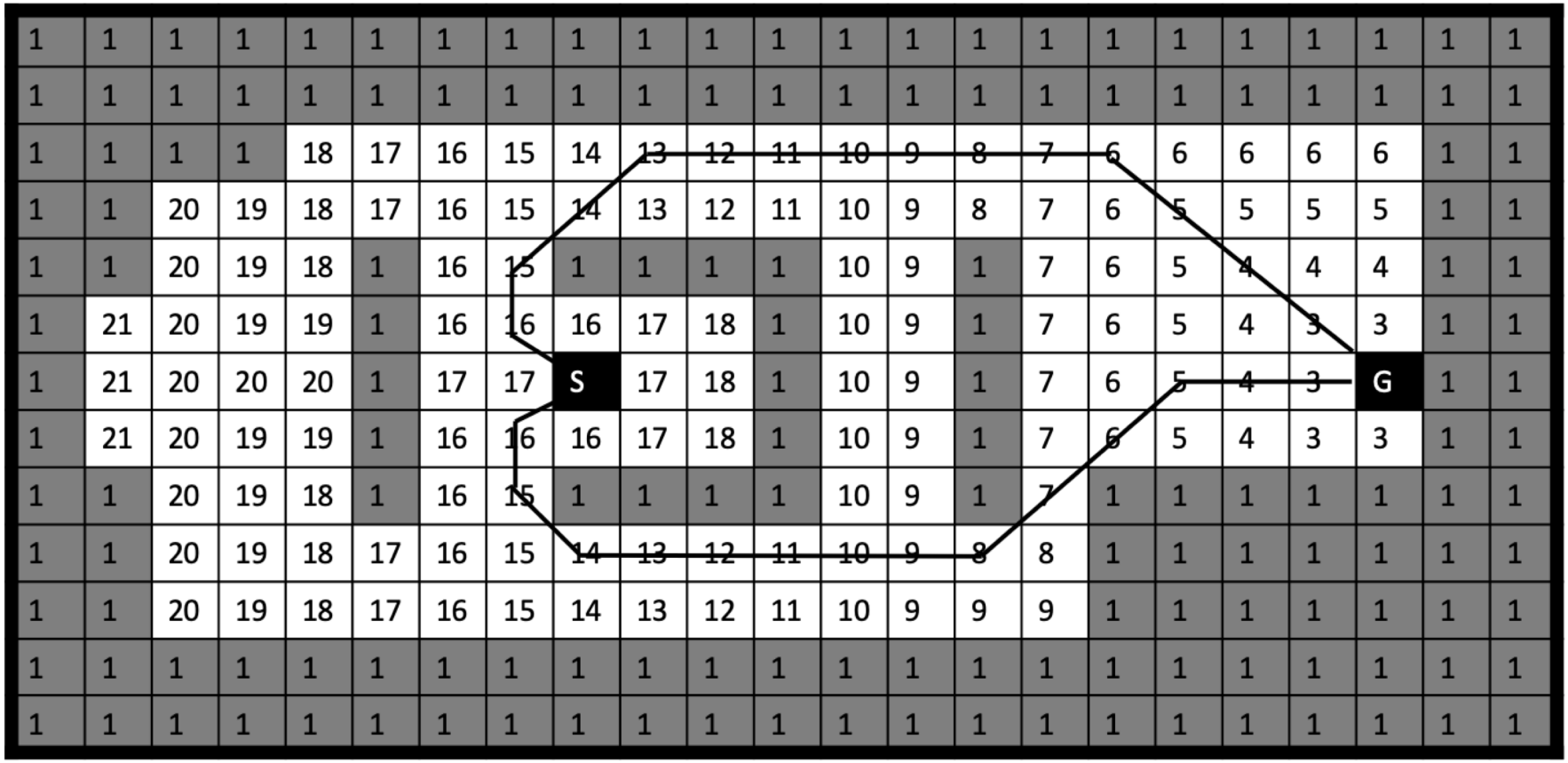
Apply the Wavefront Planner algorithm and fill the necessary cells (you do not need to fill all of them) to reach “G” from “S”. Highlight a shortest path between “S” and “G”.



WaveFront Planner

Spring 2019

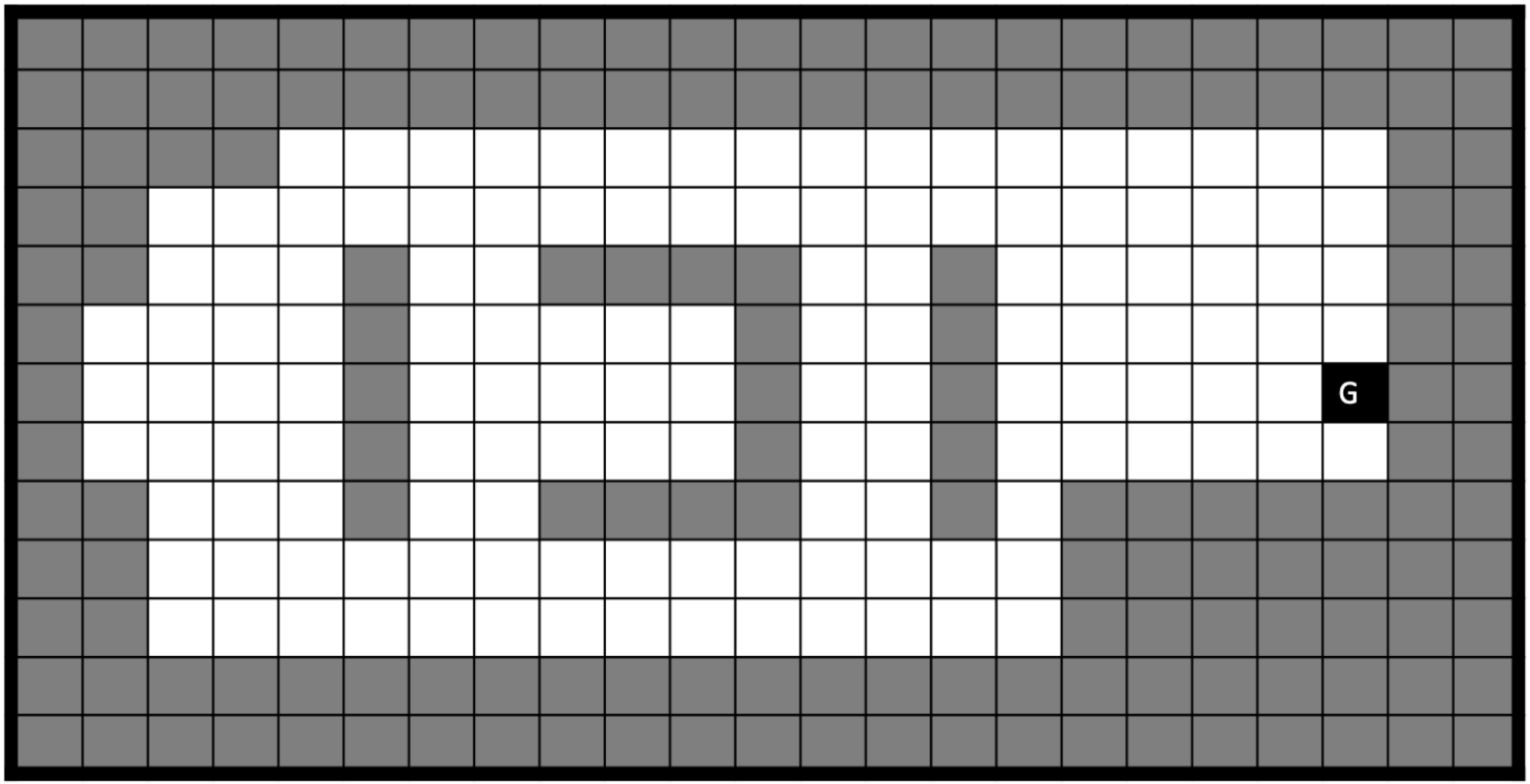
Apply the Wavefront Planner algorithm and fill the necessary cells (you do not need to fill all of them) to reach “G” from “S”. Highlight a shortest path between “S” and “G”.



WaveFront Planner

Spring 2019

Find an “S” anywhere in the diagram where the Wavefront Planner will not find a path from “S” to “G”. Renumber the necessary cells to support your solution and highlight such path. Explain your solution.



WaveFront Planner

Spring 2019

Question:

Find an “S” anywhere in the diagram where the Wavefront Planner will not find a path from “S” to “G”. Renumber the necessary cells to support your solution and highlight such path. Explain your solution.

Response:

For the Wavefront Planner algorithm, there will always be a path starting at any “S” that will reach “G”.