SolvingMazes-BFS_vs_DFS

Breadth-first Search (BFS) - Queue frontier is used
Depth-first Search (DFS) - Stack frontier is used

`maze1.txt`

This is a maze made from hash marks. `A` is the starting position and `B` is the goal or ending position

```
#####B#
##### #
####  #
#### ##
     ##
A######
```

`maze.py`

```python
import sys

class Node():
    def __init__(self, state, parent, action):
        self.state = state
        self.parent = parent
        self.action = action


class StackFrontier():
    def __init__(self):
        self.frontier = []

    def add(self, node):
        self.frontier.append(node)

    def contains_state(self, state):
        return any(node.state == state for node in self.frontier)

    def empty(self):
        return len(self.frontier) == 0

    def remove(self):
        if self.empty():
            raise Exception("empty frontier")
        else:
            node = self.frontier[-1]
            self.frontier = self.frontier[:-1]
            return node


class QueueFrontier(StackFrontier):

    def remove(self):
        if self.empty():
            raise Exception("empty frontier")
        else:
            node = self.frontier[0]
            self.frontier = self.frontier[1:]
            return node

class Maze():

    def __init__(self):
        filename = sys.argv[1]
        self.frontierType = sys.argv[2]

        self.frontiers = {'stack': StackFrontier(),
                         'queue': QueueFrontier()
                         }
        # Read file and set height and width of maze
        with open(filename) as f:
            contents = f.read()

        # Validate start and goal
        if contents.count("A") != 1:
            raise Exception("maze must have exactly one start point")
        if contents.count("B") != 1:
            raise Exception("maze must have exactly one goal")

        # Determine height and width of maze
        contents = contents.splitlines()
        self.height = len(contents)
        self.width = max(len(line) for line in contents)

        # Keep track of walls
        self.walls = []
        for i in range(self.height):
            row = []
            for j in range(self.width):
                try:
                    if contents[i][j] == "A":
                        self.start = (i, j)
                        row.append(False)
                    elif contents[i][j] == "B":
                        self.goal = (i, j)
                        row.append(False)
                    elif contents[i][j] == " ":
                        row.append(False)
                    else:
                        row.append(True)
                except IndexError:
                    row.append(False)
            self.walls.append(row)

        self.solution = None


    def print(self):
        solution = self.solution[1] if self.solution is not None else None
        print()
        for i, row in enumerate(self.walls):
            for j, col in enumerate(row):
                if col:
                    print("#", end="")
                elif (i, j) == self.start:
                    print("A", end="")
                elif (i, j) == self.goal:
                    print("B", end="")
                elif solution is not None and (i, j) in solution:
                    print("*", end="")
                else:
                    print(" ", end="")
            print()
        print()


    def neighbors(self, state):
        row, col = state
        candidates = [
            ("up", (row - 1, col)),
            ("down", (row + 1, col)),
            ("left", (row, col - 1)),
            ("right", (row, col + 1))
        ]

        result = []
        for action, (r, c) in candidates:
            if 0 <= r < self.height and 0 <= c < self.width and not self.walls[r][c]:
                result.append((action, (r, c)))
        return result


    def solve(self):
        """Finds a solution to maze, if one exists."""

        # Keep track of number of states explored
        self.num_explored = 0

        # Initialize frontier to just the starting position
        start = Node(state=self.start, parent=None, action=None)
        frontier = self.frontiers[self.frontierType] #QueueFrontier()
        frontier.add(start)

        # Initialize an empty explored set
        self.explored = set()

        # Keep looping until solution found
        while True:

            # If nothing left in frontier, then no path
            if frontier.empty():
                raise Exception("no solution")

            # Choose a node from the frontier
            node = frontier.remove()
            self.num_explored += 1

            # If node is the goal, then we have a solution
            if node.state == self.goal:
                actions = []
                cells = []
                while node.parent is not None:
                    actions.append(node.action)
                    cells.append(node.state)
                    node = node.parent
                actions.reverse()
                cells.reverse()
                self.solution = (actions, cells)
                return

            # Mark node as explored
            self.explored.add(node.state)

            # Add neighbors to frontier
            for action, state in self.neighbors(node.state):
                if not frontier.contains_state(state) and state not in self.explored:
                    child = Node(state=state, parent=node, action=action)
                    frontier.add(child)


    def output_image(self, filename, show_solution=True, show_explored=False):
        from PIL import Image, ImageDraw
        cell_size = 50
        cell_border = 2

        # Create a blank canvas
        img = Image.new(
            "RGBA",
            (self.width * cell_size, self.height * cell_size),
            "black"
        )
        draw = ImageDraw.Draw(img)

        solution = self.solution[1] if self.solution is not None else None
        for i, row in enumerate(self.walls):
            for j, col in enumerate(row):

                # Walls
                if col:
                    fill = (40, 40, 40)

                # Start
                elif (i, j) == self.start:
                    fill = (255, 0, 0)

                # Goal
                elif (i, j) == self.goal:
                    fill = (0, 171, 28)

                # Solution
                elif solution is not None and show_solution and (i, j) in solution:
                    fill = (220, 235, 113)

                # Explored
                elif solution is not None and show_explored and (i, j) in self.explored:
                    fill = (212, 97, 85)

                # Empty cell
                else:
                    fill = (237, 240, 252)

                # Draw cell
                draw.rectangle(
                    ([(j * cell_size + cell_border, i * cell_size + cell_border),
                      ((j + 1) * cell_size - cell_border, (i + 1) * cell_size - cell_border)]),
                    fill=fill
                )

        img.save(filename)


if len(sys.argv) != 3:
    sys.exit("Usage: python maze.py maze.txt frontierType(e.g stack, queue)")

m = Maze()
print("Maze:")
m.print()
print("Solving...")
m.solve()
print("States Explored:", m.num_explored)
print("Solution:")
m.print()
m.output_image("maze.png", show_explored=True)
```

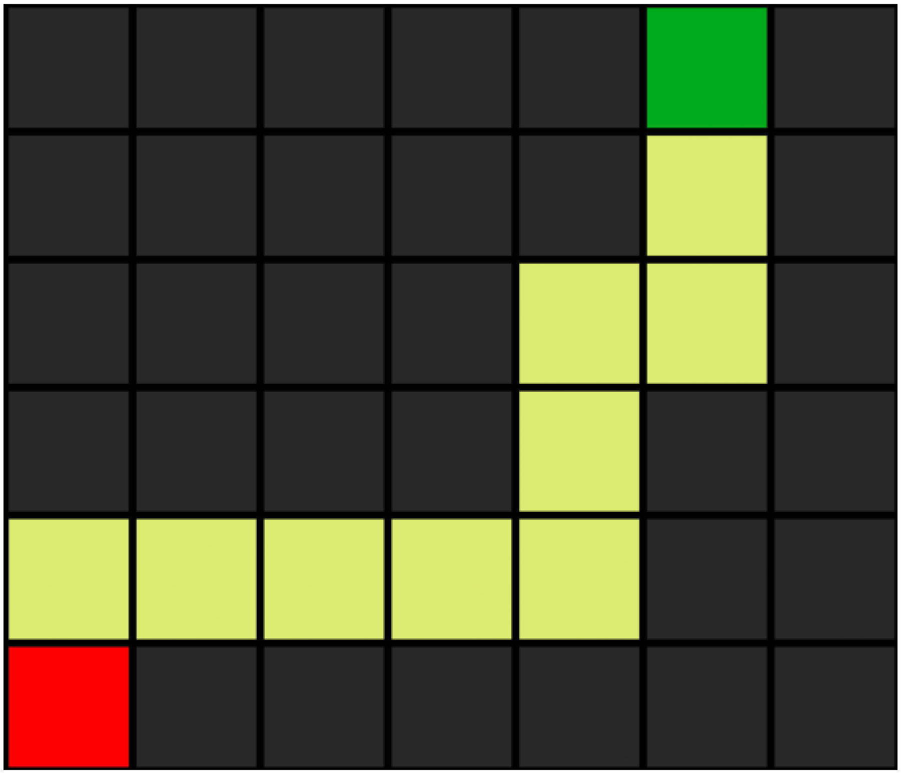
In [1]:

```
%%bash
python -i maze.py maze1.txt 'stack'
```

```
Maze:

#####B#
##### #
####  #
#### ##
     ##
A######

Solving...
States Explored: 11
Solution:

#####B#
#####*#
####**#
####*##
*****##
A######


>>>
```

In [2]:

```
import matplotlib.pyplot as plt
plt.figure(figsize=(10,10))
plt.imshow(plt.imread('./maze.png'))
plt.axis('off')
plt.show()
```



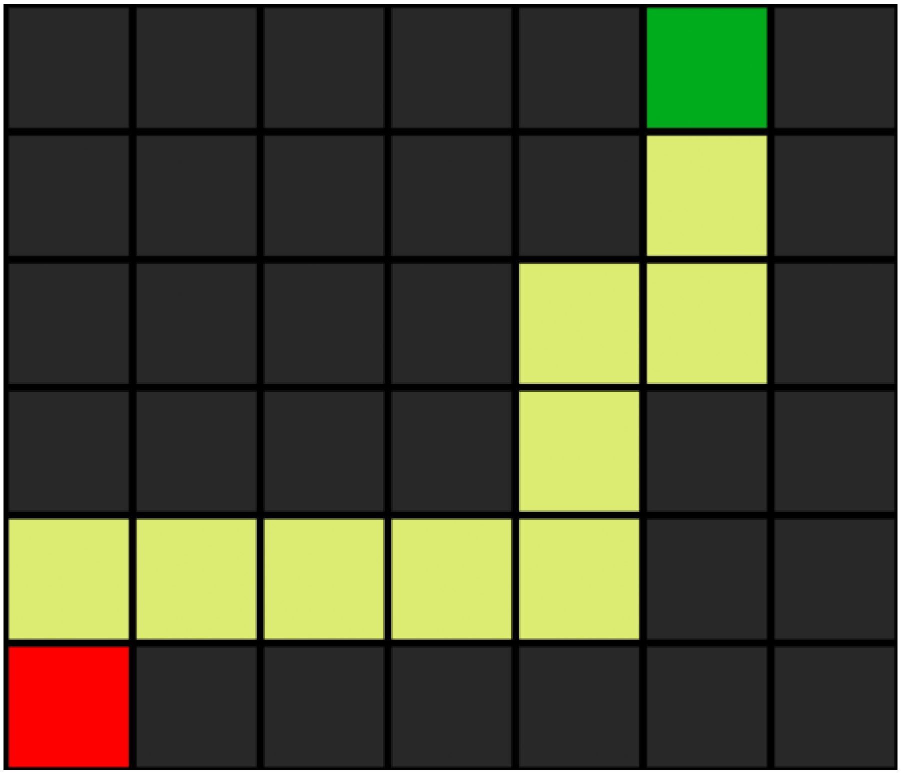
In [3]:

```
%%bash
python -i maze.py maze1.txt 'queue'
```

```
Maze:

#####B#
##### #
####  #
#### ##
     ##
A######

Solving...
States Explored: 11
Solution:

#####B#
#####*#
####**#
####*##
*****##
A######


>>>
```

In [4]:

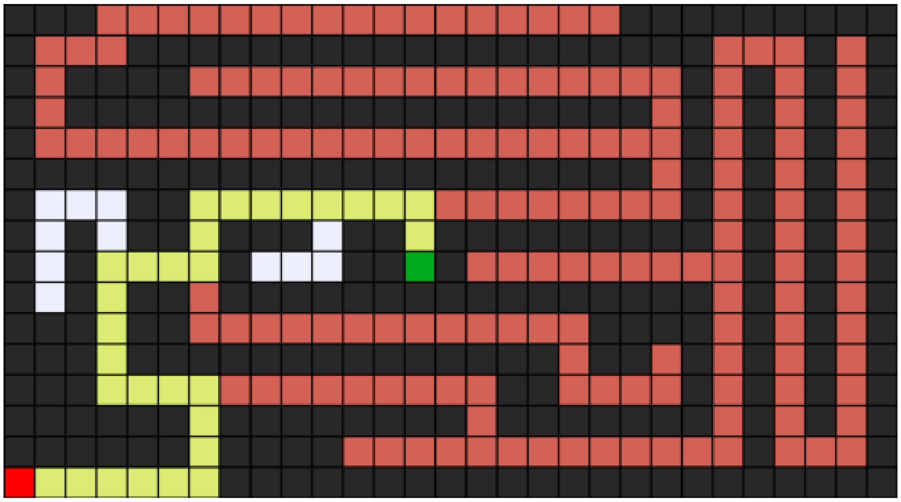
```python
import matplotlib.pyplot as plt
plt.figure(figsize=(10,10))
plt.imshow(plt.imread('./maze.png'))
plt.axis('off')
plt.show()
```



In [5]:
```
%%bash
python -i maze.py maze2.txt 'stack'
```

```
Maze:

###                 #########
#   ###################   # #
# ####                # # # #
# ################### # # # #
#                     # # # #
##################### # # # #
#   ##                # # # #
# # ## ### ## ######### # # #
# #    #   ##B#         # # #
# # ## ################ # # #
### ##             #### # # #
### ############## ## # # # #
###             ##    # # # #
###### ######## ####### # # #
###### ####             #   #
A      ######################

Solving...
States Explored: 194
Solution:

###                 #########
#   ###################   # #
# ####                # # # #
# ################### # # # #
#                     # # # #
##################### # # # #
#   ##********        # # # #
# # ##*### ##*######### # # #
# #****#   ##B#         # # #
# #*## ################ # # #
###*##             #### # # #
###*############## ## # # # #
###****         ##    # # # #
######*######## ####### # # #
######*####             #   #
A******######################



>>>
```

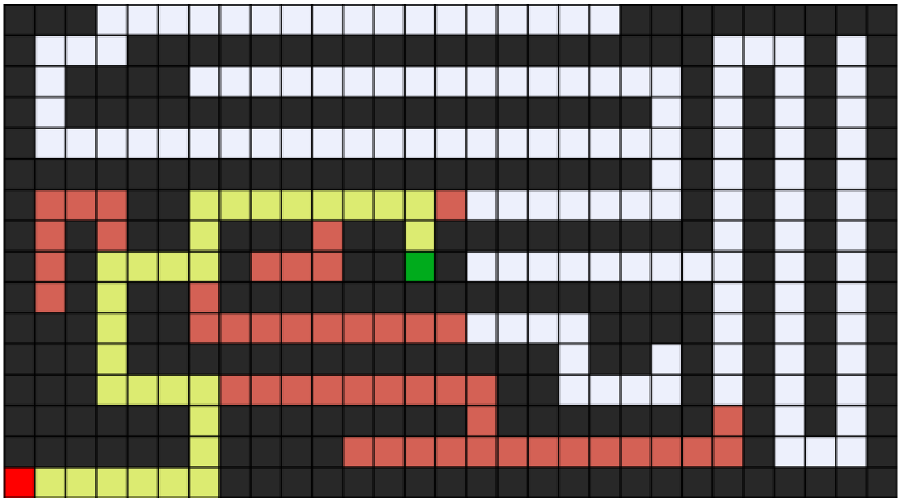
In [6]:
```
plt.figure(figsize=(10,10))
plt.imshow(plt.imread('./maze.png'))
plt.axis('off')
plt.show()
```



In [7]:
```
%%bash
python -i maze.py maze2.txt 'queue'
```

```
Maze:

###                 #########
#   ###################   # #
# ####                # # # #
# ################### # # # #
#                     # # # #
##################### # # # #
#   ##                # # # #
# # ## ### ## ######### # # #
# #    #   ##B#         # # #
# # ## ################ # # #
### ##             #### # # #
### ############## ## # # # #
###             ##    # # # #
###### ######## ####### # # #
###### ####             #   #
A      ######################

Solving...
States Explored: 77
Solution:

###                 #########
#   ###################   # #
# ####                # # # #
# ################### # # # #
#                     # # # #
##################### # # # #
#   ##********        # # # #
# # ##*### ##*######### # # #
# #****#   ##B#         # # #
# #*## ################ # # #
###*##             #### # # #
###*############## ## # # # #
###****         ##    # # # #
######*######## ####### # # #
######*####             #   #
A******######################


>>>
```

In [8]:
```
plt.figure(figsize=(10,10))
plt.imshow(plt.imread('./maze.png'))
plt.axis('off')
plt.show()
```



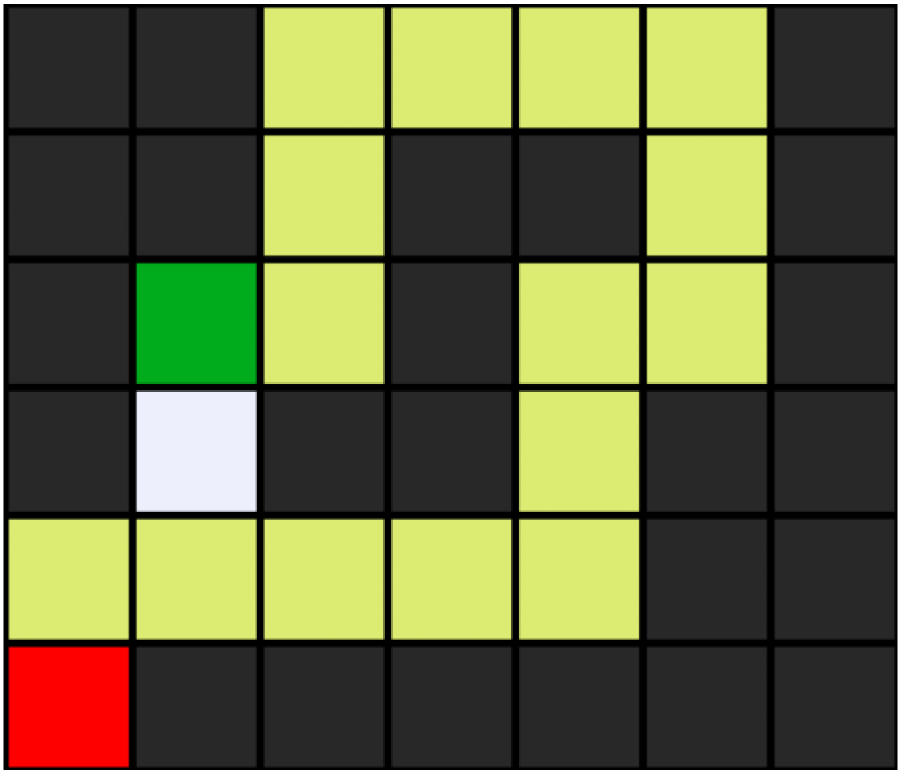
In [9]:

```
%%bash
python -i maze.py maze3.txt 'stack'
```

```
Maze:

##    #
## ## #
#B #  #
# ## ##
     ##
A######

Solving...
States Explored: 17
Solution:

##****#
##*##*#
#B*#**#
# ##*##
*****##
A######



>>>
```

In [10]:

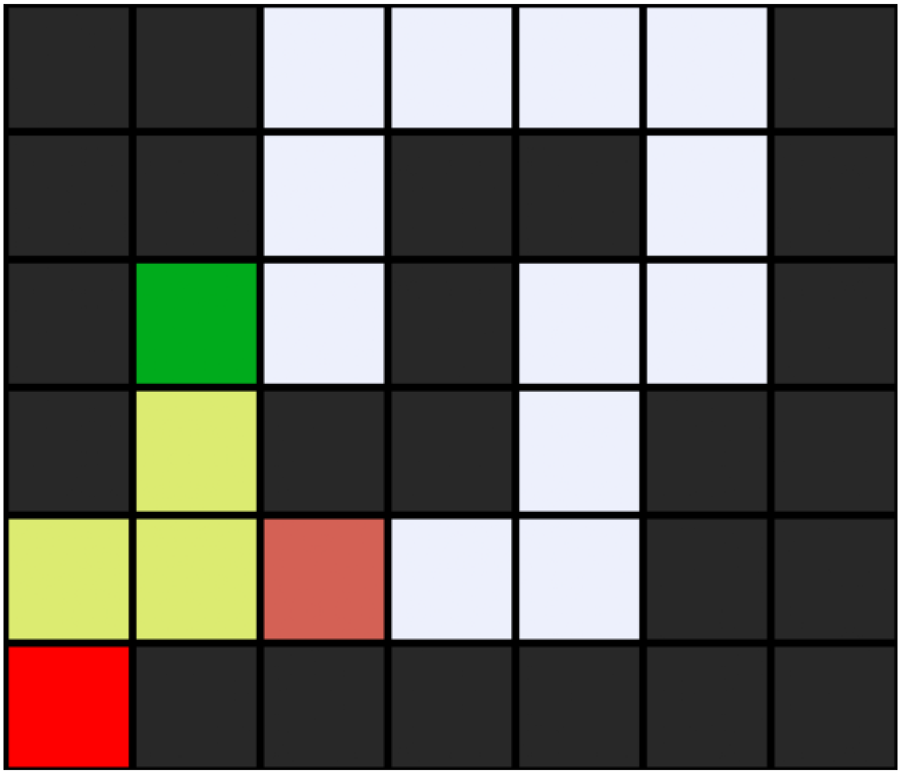
```
plt.figure(figsize=(10,10))
plt.imshow(plt.imread('./maze.png'))
plt.axis('off')
plt.show()
```



In [11]:
```
%%bash
python -i maze.py maze3.txt 'queue'
```

```
Maze:

##    #
## ## #
#B #  #
# ## ##
     ##
A######

Solving...
States Explored: 6
Solution:

##    #
## ## #
#B #  #
#*## ##
**   ##
A######


>>>
```

In [12]:
```
plt.figure(figsize=(10,10))
plt.imshow(plt.imread('./maze.png'))
plt.axis('off')
plt.show()
```



In [ ]:

```
%%writefile ./maze0.txt
###           ####      #####
### ### ## ## #### #### #####
### ### ## ## #### ####
##                  ### ### #
## ### ################ ### #
## ### #####            ### #
## ###      B####### ## ### #
## #### #### ####### ## ### #
## ##    ### ###
##  ### #### ########## ####
### ##   ###       #### ####
### #### ######### #### ####
###A      ########      ####
###
#############################
```

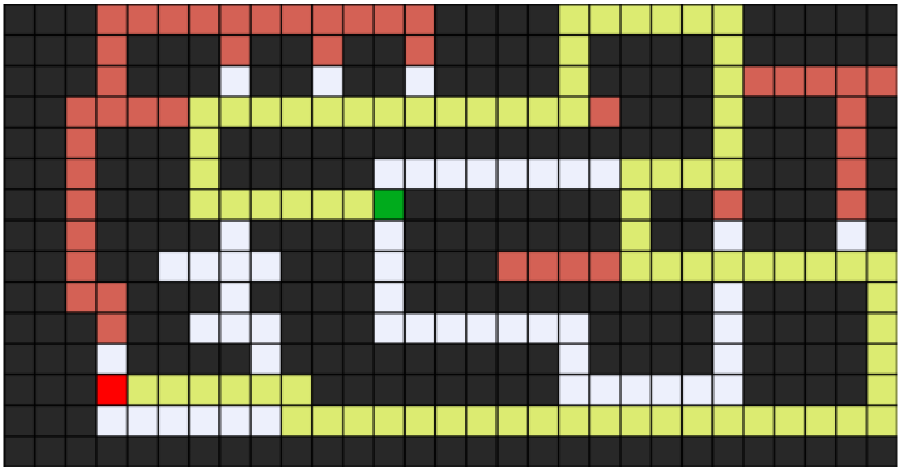
In [14]:

```
%%bash
python -i maze.py maze0.txt 'stack'
```

```
Maze:

###           ####      #####
### ### ## ## #### #### #####
### ### ## ## #### ####
##                  ### ### #
## ### ################ ### #
## ### #####            ### #
## ###      B####### ## ### #
## #### #### ####### ## ### #
## ##    ### ###
##  ### #### ########## ####
### ##   ###       #### ####
### #### ######### #### ####
###A      ########      ####
###
#############################

Solving...
States Explored: 123
Solution:

###           ####******#####
### ### ## ## ####*####*#####
### ### ## ## ####*####*
##    ************* ###*### #
## ###*################*### #
## ###*#####        ****### #
## ###******B#######*## ### #
## #### #### #######*## ### #
## ##    ### ###    *********
##  ### #### ########## ####*
### ##   ###       #### ####*
### #### ######### #### ####*
###A******########      ####*
###      ********************
#############################


>>>
```

In [15]:
```
plt.figure(figsize=(10,10))
plt.imshow(plt.imread('./maze.png'))
plt.axis('off')
plt.title('Stack frontier finds a suboptimal solution and requires more exploration')
plt.show()
```

Stack frontier finds a suboptimal solution and requires more exploration

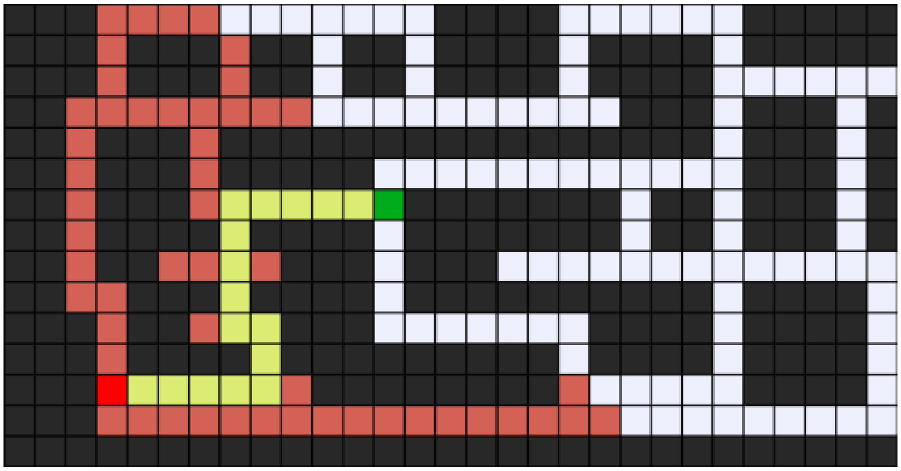


In [16]:
```
%%bash
python -i maze.py maze0.txt 'queue'
```

```
Maze:

###           ####      #####
### ### ## ## #### #### #####
### ### ## ## #### ####
##                  ### ### #
## ### ################ ### #
## ### #####            ### #
## ###      B####### ## ### #
## #### #### ####### ## ### #
## ##    ### ###
##  ### #### ########## ####
### ##   ###       #### ####
### #### ######### #### ####
###A      ########      ####
###
#############################

Solving...
States Explored: 69
Solution:

###           ####      #####
### ### ## ## #### #### #####
### ### ## ## #### ####
##                  ### ### #
## ### ################ ### #
## ### #####            ### #
## ### *****B####### ## ### #
## ####*#### ####### ## ### #
## ##  * ### ###
##  ###*#### ########## ####
### ## **###       #### ####
### ####*######### #### ####
###A***** ########      ####
###
#############################



>>>
```

In [17]:
```
plt.figure(figsize=(10,10))
plt.imshow(plt.imread('./maze.png'))
plt.axis('off')
plt.title('Queue frontier requires fewer exploration and finds the optimal solution to the maze')
plt.show()
```

Queue frontier requires fewer exploration and finds the optimal solution to the maze



In [ ]: