Q1. [20 pts] Search

It is training day for Pacbabies, also known as Hungry Running Maze Games day. Each of k Pacbabies starts in its own assigned start location s_i in a large maze of size $M \times N$ and must return to its own Pacdad who is waiting patiently but proudly at g_i along the way, the Pacbabies must, between them, eat all the dots in the maze.

At each step, all k Pacbabies move one unit to any open adjacent square. The only legal actions are Up, Down, Left, or Right. It is illegal for a Pacbaby to wait in a square, attempt to move into a wall, or attempt to occupy the same square as another Pacbaby. To set a record, the Pacbabies must find an optimal collective solution.

1.1) (7 pts) Define a minimal state space representation for this problem.

The state space should include all the Pacbabies' states and all the dots' state in the $M \times N$ space.
The minimum state space can be defined as a tuple [P, D] where:
P is a set of all the k pacbabies: $\{P_1, P_2 .. P_i .. P_k\}$, where P_i means the i-th Pacbaby
D is a set of all the dots to be eaten: $\{D_1, D_2 \cdots D_j \cdots D_{M\times N}\}$, where D_j means the j-th dot.
Note: The definition of state space is referenced from Wikipedia

1.2) (5 pts) How large is the state space?

For each pacbaby, there is $M\times N$ potential locations, so the size of pacbabies is $(M\times N)^k$
For the dots, only have 2 states which are presence and be eaten, the total size is $2^{(M\times N)}$
There for the size of the whole state space is: $(M\times N)^k \times 2^{(M\times N)}$

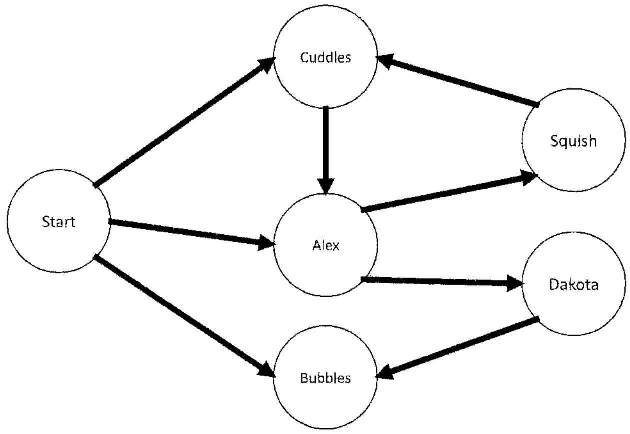
1.3) (8 pts) What is the maximum branching factor for this problem? Explain your choice.

A) 4^k ✓
B) 8^k
C) $4^k 2^{MN}$
D) $4^k 2^4$

The answer is A, because there are only 4 actions for every pacbaby which are Up, Down, Left, or Right. The total should be 4^k where k is the count of pacbabies.

Q2. [22 pts]Search: Snail search for love

Scorpblorg the snail is looking for a mate. It can visit different potential mates based on a trail of ooze to nearby snails, and then test them for chemistry, as represented in the below graph, where each node represents a snail. In all cases, nodes with equal priority should be visited in alphabetical order.



(a) (8 pts) Simple search

In this part, assume that the only match for Scorpblorg is Squish (i.e. Squish is the goal state). Which of the following are true **when searching the above graph**?

(i) BFS Tree Search expands more nodes than DFS Tree Search ✓ True ○ False

(ii) DFS Tree Search finds a path to the goal for this graph ✓ True ○ False

(iii) DFS Graph Search finds the shortest path to the goal for this graph ✓ True ○ False

(iv) If we remove the connection from Cuddles → Alex, can DFS Graph Search find a path to the goal for the altered graph? ✓ Yes ○ No

(b) (8 pts) Third Time 's A Charm

Now we assume that Scorpblorg's mate preferences have changed. The new criteria she is looking for in a mate is that she has **visited the mate twice before** (i.e. when she visits any state for the third time, she has found a path to the goal).

(i) What should the most simple yet sufficient new state space representation include?

- ☑ The current location of Scorpblorg
- ☐ The total number of edges travelled so far
- ☐ An array of booleans indicating whether each snail has been visited so far can or cannot?
- ☑ An array of numbers indicating how many times each snail has been visited so far
- ☐ The number of distinct snails visited so far

(ii) DFS Tree Search finds a path to the goal for this graph ✓ True ○ False

(iii) BFS Graph Search finds a path to the goal for this graph ✓ True ○ False

(iv) If we remove the connection from Cuddles → Alex, can DFS Graph Search finds a path to the goal for the altered graph? ○ Yes ✓ No

We continue as in part (b) where the goal is still to find a mate who is visited for the third time.

(c) (4 pts) Costs for visiting snails

Assume we are using Uniform cost search and we can now add costs to the actions in the graph.

(i) Can one assign (non-negative) costs to the actions in the graph such that the goal state returned by UCS (Tree-search) changes? ✓ Yes ○ No

(ii) Can one assign (potentially negative) costs to the actions in the graph such that UCS (Tree-search) will never find a goal state? ○ Yes ✓ No