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<u>4.1</u>

a) Hill-Climbing

b) BFS

c) Hill-Climbing

d) Random

e) Random

<u>5.1</u>

a)

- States: The placement of the tiles and blank tiles on both of the 8-puzzles
- Initial State: Any two arbitrary states for 8-puzzles
- Actions: Move the empty space on either board up, down, left or right
- Transition Model: Make one move on one of the puzzles
- Goal Test: If both of the puzzles are solved

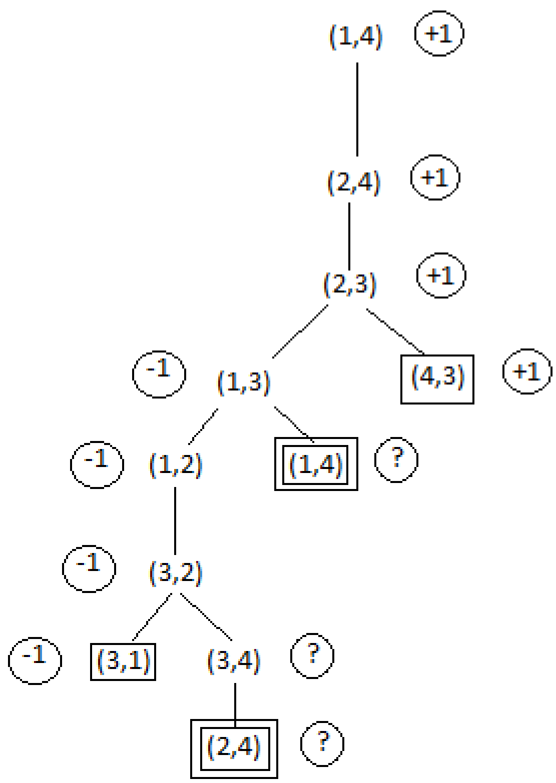
b) Each puzzle has 9!/2 total states, so these two puzzles have $(9!/2)^2$ states.

c) Expectiminimax would work, since there is randomization involved.

d) The game will never end, since an optimal agent would not want to leave a board one space from being solved as this would mean the opponent has a 50-50 chance of being able to solve it.

<u>5.8</u>

a)



b) Assuming that both players play optimally, they will take a winning state when available to them, a looped state will never occur, as the player has a choice to win or enter a loop state.

c) Since Minimax is Depth-First, the algorithm may not return a value since it will get stuck in a looped state. To avoid this, we could try to assign a value to a looped state, for example by assigning it the value it had when it was first encountered. This would definitely not work for all games with loops. It only works here since picking a looped state is tantamount to losing the game.

d)

Proof for odd n:

Assume that A moves first, and that there are n squares, where n is odd. Base Case: Let n = 3. Since both players have only one move to choose in the beginning, the only sequence of states possible is :(1, 3) → (2, 3) → (2, 1), hence B wins. Now let n > 2 (n still odd) and suppose that A wins the game of order less than or equal to n. Consider the game of size n + 2. The first two moves will have A move left, and B move right. If both players continue to move towards each other, this is identical to the game of size n and B will win. If A ever takes a step backwards, B can continue to advance to keep the distance between them odd, hence B has a winning strategy.

This proof looks nearly identical for the n even case, so we need only prove the base case, and as seen in a), in the n=4 case, A has a winning strategy.

Sudoku Solver Output:

All outputs are correct

```
test1:
3 9 1 4 7 6 8 5 2
6 7 2 9 8 5 1 3 4
8 5 4 1 2 3 7 9 6
2 1 6 8 3 4 5 7 9
5 4 8 7 9 1 2 6 3
9 3 7 6 5 2 4 8 1
1 8 3 2 6 7 9 4 5
7 2 5 3 4 9 6 1 8
4 6 9 5 1 8 3 2 7
Time taken: 29.82855 milliseconds

test2:
3 9 5 6 7 4 8 1 2
6 7 1 9 8 2 4 3 5
8 2 4 1 5 3 7 9 6
9 1 6 2 3 8 5 7 4
5 4 8 7 9 1 2 6 3
2 3 7 4 6 5 9 8 1
1 8 3 5 2 7 6 4 9
7 6 2 3 4 9 1 5 8
4 5 9 8 1 6 3 2 7
Time taken: 711.954179 milliseconds

test3:
5 1 9 3 4 2 7 8 6
2 3 7 5 8 6 9 4 1
4 6 8 1 7 9 5 3 2
7 5 6 2 3 1 4 9 8
8 2 3 4 9 7 1 6 5
1 9 4 8 6 5 2 7 3
6 4 2 9 5 8 3 1 7
9 8 5 7 1 3 6 2 4
3 7 1 6 2 4 8 5 9
Time taken: 6.650191 milliseconds
```

```
test4:
1 6 9 2 3 7 8 4 5
8 7 3 9 4 5 2 1 6
2 5 4 6 8 1 9 3 7
3 4 6 8 1 9 7 5 2
5 1 8 7 2 3 4 6 9
7 9 2 5 6 4 3 8 1
4 3 7 1 5 2 6 9 8
9 8 5 4 7 6 1 2 3
6 2 1 3 9 8 5 7 4
Time taken: 1.365504 milliseconds

test5:
2 6 8 7 1 5 4 9 3
5 1 4 3 9 8 2 6 7
3 9 7 4 6 2 5 1 8
4 2 6 1 3 9 7 8 5
7 3 5 6 8 4 9 2 1
9 8 1 2 5 7 3 4 6
1 4 3 5 2 6 8 7 9
6 7 9 8 4 3 1 5 2
8 5 2 9 7 1 6 3 4
Time taken: 0.864883 milliseconds
```