

Rajeev Atla

~~Settlers of Catan~~ A board game is played on a hexagonal grid of 19 tiles. A 'traveler' token starts on the center tile. Each turn a die is rolled to determine what neighboring tile the traveler moves to (all six directions equally likely). The turn that the traveler leaves the board, the game ends. What is the expected number of turns of the game?

A diagram of a hexagonal lattice structure. The central cell is labeled 0 and contains a red dot. Cells 1 through 14 are labeled with black numbers and contain red dots. Cells 15 through 36 are labeled with black numbers and contain green dots. The lattice is surrounded by 24 green dots labeled 19 through 42, which are not part of the lattice cells.

We wish to find the expected value of the number of turns in the game, which we denote N .

The dice is truly random, so there is no upper bound on N . We note that this game is really akin to a Markov chain, in that it doesn't matter what the past states are.

$N =$	$P_{0,0} = \frac{45}{16}$	$P_{0,1} = \frac{15}{16}$	$P_{0,2} = \frac{15}{16}$	$P_{0,3} = \frac{15}{16}$	$P_{0,4} = \frac{15}{16}$	$P_{0,5} = \frac{15}{16}$	$P_{0,6} = \frac{15}{16}$	$P_{0,7} = \frac{7}{2}$	$P_{0,8} = \frac{5}{4}$	$P_{0,9} = \frac{7}{2}$	$P_{0,10} = \frac{15}{16}$	$P_{0,11} = \frac{7}{2}$	$P_{0,12} = \frac{5}{4}$	$P_{0,13} = \frac{7}{2}$	$P_{0,14} = \frac{5}{4}$	$P_{0,15} = \frac{7}{2}$	$P_{0,16} = \frac{5}{4}$	$P_{0,17} = \frac{7}{2}$	$P_{0,18} = \frac{5}{4}$
	$P_{1,0} = \frac{15}{16}$	$P_{1,1} = \frac{10571}{16384}$	$P_{1,2} = \frac{63005}{16384}$	$P_{1,3} = \frac{63005}{16384}$	$P_{1,4} = \frac{10571}{16384}$	$P_{1,5} = \frac{15}{16}$	$P_{1,6} = \frac{15}{16}$	$P_{1,7} = \frac{15}{16}$	$P_{1,8} = \frac{22965}{16384}$	$P_{1,9} = \frac{15}{16}$	$P_{1,10} = \frac{15}{16}$	$P_{1,11} = \frac{15}{16}$	$P_{1,12} = \frac{22965}{16384}$	$P_{1,13} = \frac{15}{16}$	$P_{1,14} = \frac{22965}{16384}$	$P_{1,15} = \frac{15}{16}$	$P_{1,16} = \frac{15}{16}$	$P_{1,17} = \frac{15}{16}$	$P_{1,18} = \frac{15}{16}$
	$P_{2,0} = \frac{15}{16}$	$P_{2,1} = \frac{15}{16}$	$P_{2,2} = \frac{15}{16}$	$P_{2,3} = \frac{15}{16}$	$P_{2,4} = \frac{15}{16}$	$P_{2,5} = \frac{15}{16}$	$P_{2,6} = \frac{15}{16}$	$P_{2,7} = \frac{15}{16}$	$P_{2,8} = \frac{22965}{16384}$	$P_{2,9} = \frac{15}{16}$	$P_{2,10} = \frac{15}{16}$	$P_{2,11} = \frac{15}{16}$	$P_{2,12} = \frac{15}{16}$	$P_{2,13} = \frac{15}{16}$	$P_{2,14} = \frac{15}{16}$	$P_{2,15} = \frac{15}{16}$	$P_{2,16} = \frac{15}{16}$	$P_{2,17} = \frac{15}{16}$	$P_{2,18} = \frac{15}{16}$
	$P_{3,0} = \frac{15}{16}$	$P_{3,1} = \frac{15}{16}$	$P_{3,2} = \frac{15}{16}$	$P_{3,3} = \frac{15}{16}$	$P_{3,4} = \frac{15}{16}$	$P_{3,5} = \frac{15}{16}$	$P_{3,6} = \frac{15}{16}$	$P_{3,7} = \frac{15}{16}$	$P_{3,8} = \frac{15}{16}$	$P_{3,9} = \frac{15}{16}$	$P_{3,10} = \frac{15}{16}$	$P_{3,11} = \frac{15}{16}$	$P_{3,12} = \frac{15}{16}$	$P_{3,13} = \frac{15}{16}$	$P_{3,14} = \frac{15}{16}$	$P_{3,15} = \frac{15}{16}$	$P_{3,16} = \frac{15}{16}$	$P_{3,17} = \frac{15}{16}$	$P_{3,18} = \frac{15}{16}$
	$P_{4,0} = \frac{15}{16}$	$P_{4,1} = \frac{15}{16}$	$P_{4,2} = \frac{15}{16}$	$P_{4,3} = \frac{15}{16}$	$P_{4,4} = \frac{15}{16}$	$P_{4,5} = \frac{15}{16}$	$P_{4,6} = \frac{15}{16}$	$P_{4,7} = \frac{15}{16}$	$P_{4,8} = \frac{15}{16}$	$P_{4,9} = \frac{15}{16}$	$P_{4,10} = \frac{15}{16}$	$P_{4,11} = \frac{15}{16}$	$P_{4,12} = \frac{15}{16}$	$P_{4,13} = \frac{15}{16}$	$P_{4,14} = \frac{15}{16}$	$P_{4,15} = \frac{15}{16}$	$P_{4,16} = \frac{15}{16}$	$P_{4,17} = \frac{15}{16}$	$P_{4,18} = \frac{15}{16}$
	$P_{5,0} = \frac{15}{16}$	$P_{5,1} = \frac{15}{16}$	$P_{5,2} = \frac{15}{16}$	$P_{5,3} = \frac{15}{16}$	$P_{5,4} = \frac{15}{16}$	$P_{5,5} = \frac{15}{16}$	$P_{5,6} = \frac{15}{16}$	$P_{5,7} = \frac{15}{16}$	$P_{5,8} = \frac{15}{16}$	$P_{5,9} = \frac{15}{16}$	$P_{5,10} = \frac{15}{16}$	$P_{5,11} = \frac{15}{16}$	$P_{5,12} = \frac{15}{16}$	$P_{5,13} = \frac{15}{16}$	$P_{5,14} = \frac{15}{16}$	$P_{5,15} = \frac{15}{16}$	$P_{5,16} = \frac{15}{16}$	$P_{5,17} = \frac{15}{16}$	$P_{5,18} = \frac{15}{16}$
	$P_{6,0} = \frac{15}{16}$	$P_{6,1} = \frac{15}{16}$	$P_{6,2} = \frac{15}{16}$	$P_{6,3} = \frac{15}{16}$	$P_{6,4} = \frac{15}{16}$	$P_{6,5} = \frac{15}{16}$	$P_{6,6} = \frac{15}{16}$	$P_{6,7} = \frac{15}{16}$	$P_{6,8} = \frac{15}{16}$	$P_{6,9} = \frac{15}{16}$	$P_{6,10} = \frac{15}{16}$	$P_{6,11} = \frac{15}{16}$	$P_{6,12} = \frac{15}{16}$	$P_{6,13} = \frac{15}{16}$	$P_{6,14} = \frac{15}{16}$	$P_{6,15} = \frac{15}{16}$	$P_{6,16} = \frac{15}{16}$	$P_{6,17} = \frac{15}{16}$	$P_{6,18} = \frac{15}{16}$
	$P_{7,0} = \frac{7}{2}$	$P_{7,1} = \frac{15}{16}$	$P_{7,2} = \frac{15}{16}$	$P_{7,3} = \frac{15}{16}$	$P_{7,4} = \frac{15}{16}$	$P_{7,5} = \frac{7}{2}$	$P_{7,6} = \frac{15}{16}$	$P_{7,7} = \frac{15}{16}$	$P_{7,8} = \frac{15}{16}$	$P_{7,9} = \frac{15}{16}$	$P_{7,10} = \frac{15}{16}$	$P_{7,11} = \frac{15}{16}$	$P_{7,12} = \frac{15}{16}$	$P_{7,13} = \frac{15}{16}$	$P_{7,14} = \frac{15}{16}$	$P_{7,15} = \frac{15}{16}$	$P_{7,16} = \frac{15}{16}$	$P_{7,17} = \frac{15}{16}$	$P_{7,18} = \frac{15}{16}$
	$P_{8,0} = \frac{5}{4}$	$P_{8,1} = \frac{15}{16}$	$P_{8,2} = \frac{15}{16}$	$P_{8,3} = \frac{15}{16}$	$P_{8,4} = \frac{15}{16}$	$P_{8,5} = \frac{5}{4}$	$P_{8,6} = \frac{15}{16}$	$P_{8,7} = \frac{15}{16}$	$P_{8,8} = \frac{15}{16}$	$P_{8,9} = \frac{15}{16}$	$P_{8,10} = \frac{15}{16}$	$P_{8,11} = \frac{15}{16}$	$P_{8,12} = \frac{15}{16}$	$P_{8,13} = \frac{15}{16}$	$P_{8,14} = \frac{15}{1$				

$$t = N\mathbf{1}$$
[illegible]

Finally, we see that $t_0 = \boxed{\frac{213}{29} \approx 7.345}$