Carcassonne (Sort of...)

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Motivation

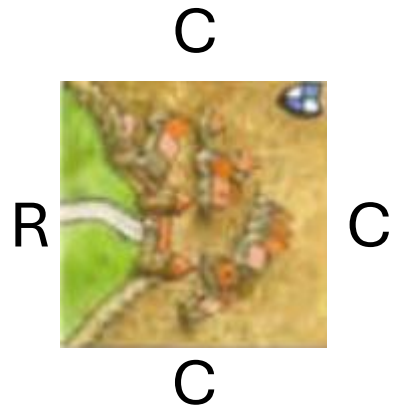
- We like the game
- It's fun
- That’s it

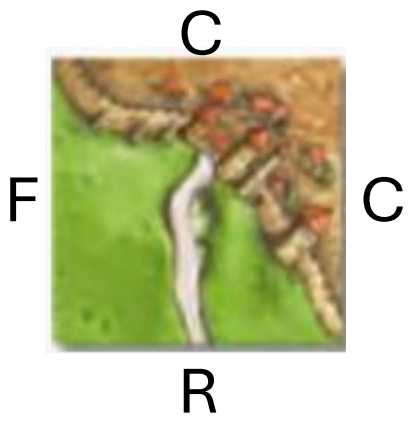
Basic Rules

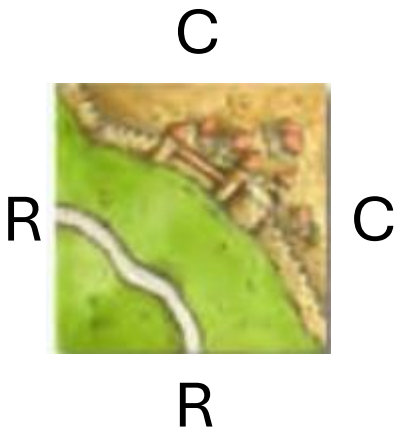
- 2-5 players
- Each player has 7 meeples to claim structures
- Draw a tile each turn
- Build cities, roads and claim them to get points
- Battle for cities
- Accumulate points by closing roads, cities, and monasteries
- Cities are 2 points per tile, roads are 1 point per tile, developed monasteries are 9 points
- Player with most points win
- At the end of the game, you get one point for each uncompleted city tile, road, and monastery

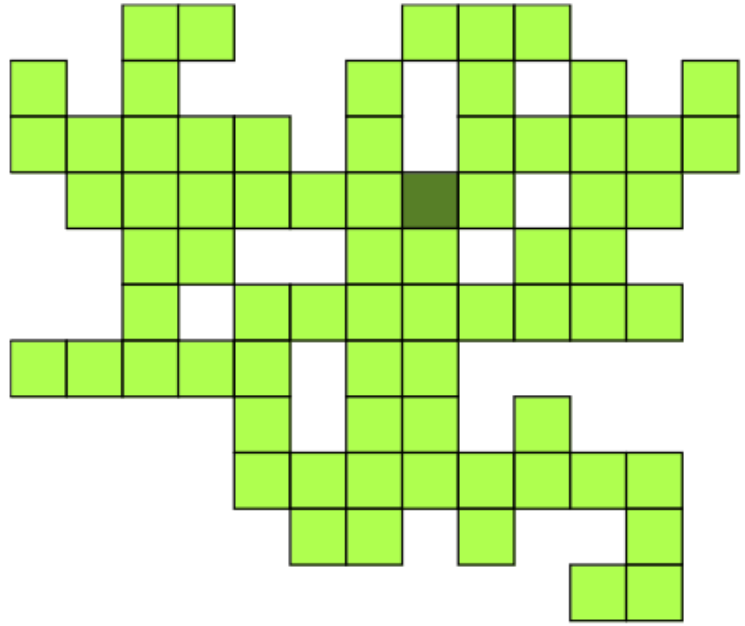
Tile Placing

- Match tiles with corresponding fields, cities, or roads









First Approach

- Let X_n denote the number of unfinished cities after the nth randomly selected tile has been placed.
- Note $X_0 = 1$ since the starting tile has a city
- In this case $X_{28} = 6$

Major Concern

- If we have $X_n > 2$ then we can't keep track of which cities were closed

$X_3 = 2$

$X_4 = 0$

More Concerns

- State space
  - 72 tiles
  - Tile placement depends on the current state of the board
  - Not all tiles are compatible
- Scoring system
  - Player only gets points when a structure is complete
  - The points obtained depend on the size of the structure
  - Some points not scored until conclusion of game
- Available tiles decrease with each turn
  - Game ends when there are no tiles left to draw from
  - Probabilities depend on the turn

Office Hour Approach

- Simplifying the state space
  - Reduce the available tiles
    - Only include cities and roads
  - Only consider 2 players

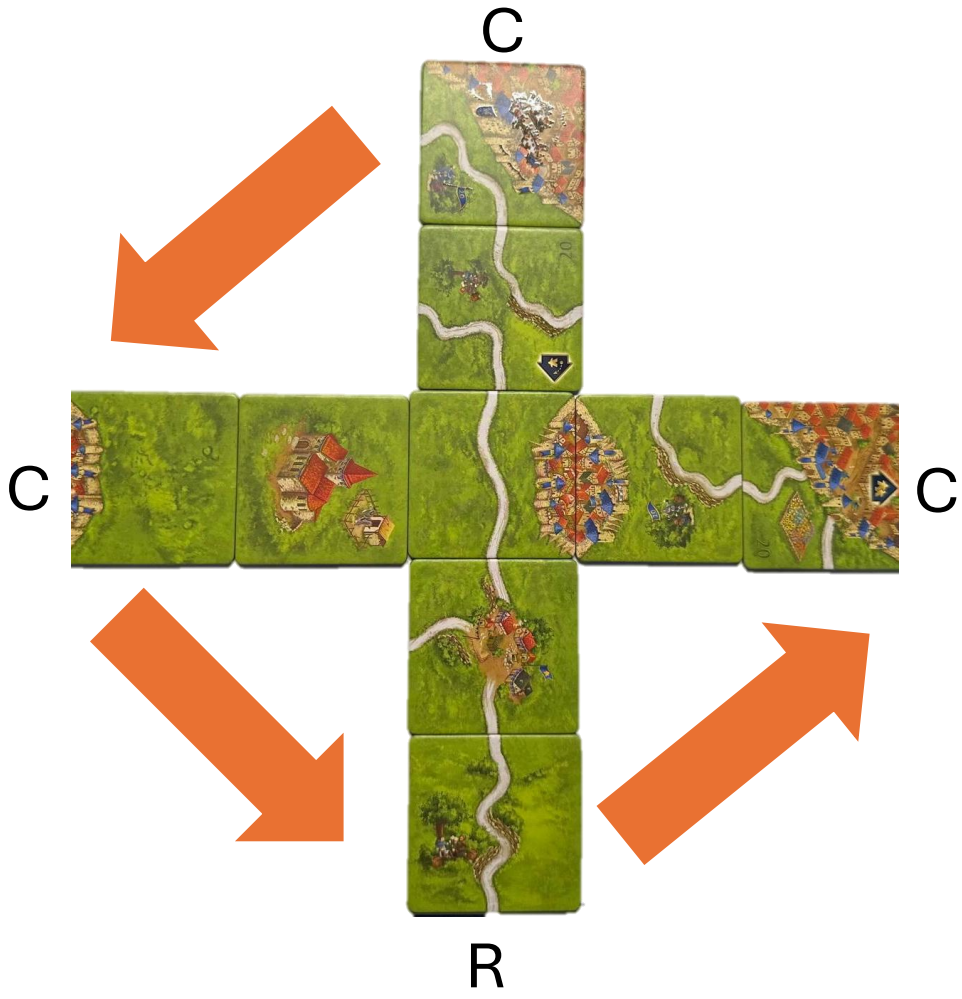
- Drawn tiles are "replaced"
  - Probabilities no longer depend on the turn

Office hour Approach Continued…

- Established a new scoring system
  - Player 1 obtains points by making endpoints cities
  - Player 2 obtains points by making endpoints roads
  - A player obtains one point for every endpoint that is a city/road
    - First player to reach four points wins
- Add restrictions to tile placement
  - Restrict the board to place tiles in a cross system

State space (32 states)

- Ordered pair
  - Players turn (1 or 2)
  - Current state of the board's end points
    - 4-character string
      - “R" denoting a road endpoint
      - “C" denoting a city endpoint
- Example: (CCRC, 1)
  - Turn: player 1
  - Top endpoint: city
  - Left endpoint: city
  - Bottom endpoint: road
  - Right endpoint: city

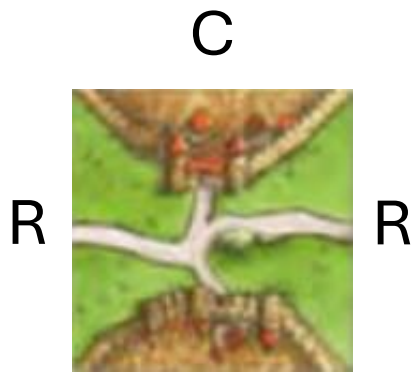


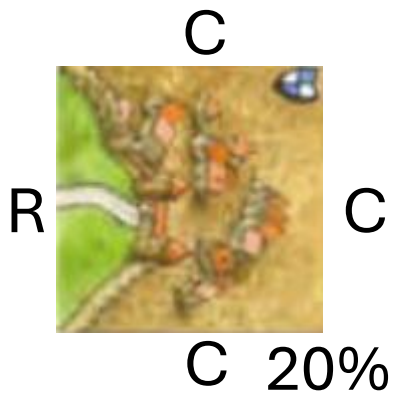
Initial conditions

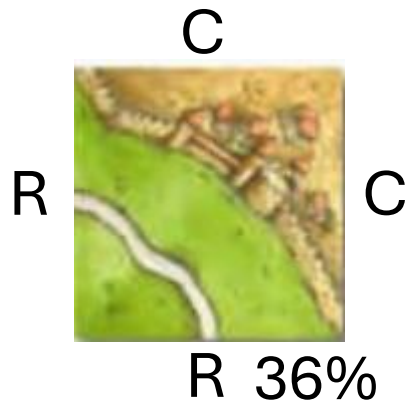
- Analyzed 6 initial conditions
  - Initial board state:
    - Fair initial states:
    - Tiles as initial states:
  - Starting player:
    - Player 1 starts
    - Player 2 starts
    - Equal chance of starting

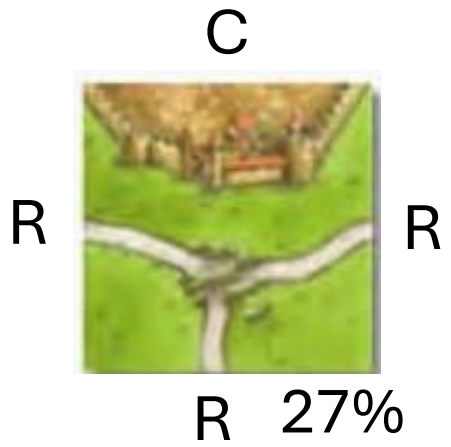
Transition probabilities

- Tile probabilities:
  - ‘CRCR': 17%
    - C-C on opposite sides
    - R-R on opposite sides
  - ’CCCR': 20%
    - C-R on opposite sides
    - C-C on opposite sides
  - ’CCRR': 36%
    - C-R on opposite sides
  - ’CRRR': 27%
    - C-R on opposite sides
    - R-R on opposite sides
- Players use the tiles differently:
  - Players prioritize making endpoints roads/cities
  - The next priority is keeping the current state



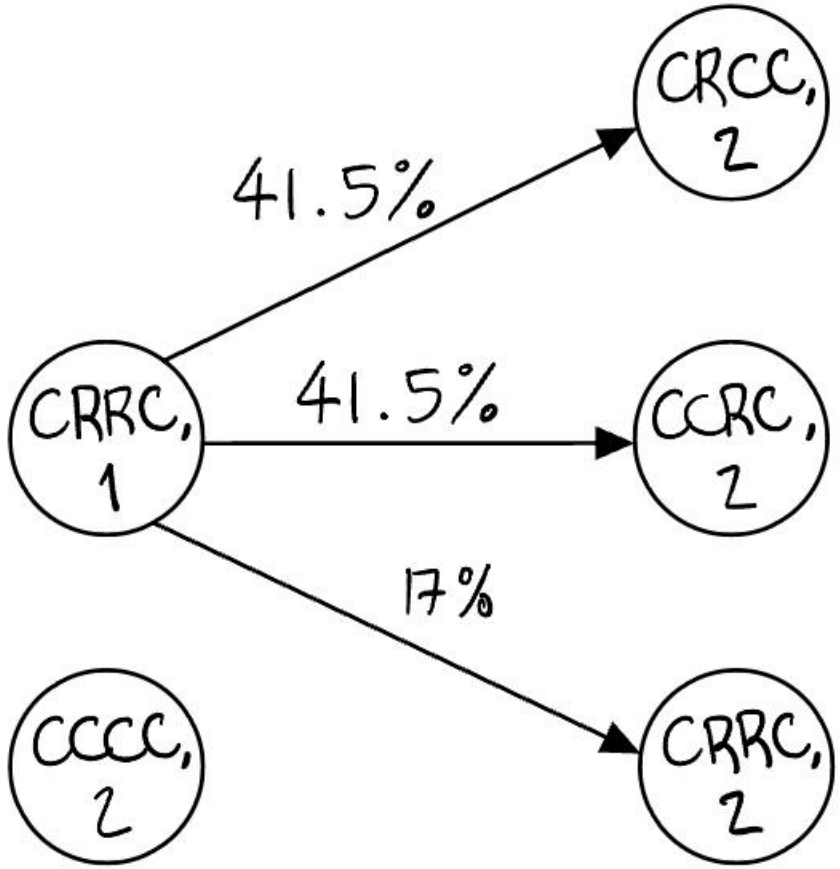






Transition Probabilities Continued …

Graphical description (segment):



Conclusions

Winning odds	Player 1 starts		Player 2 starts		Equal chance of starting	
	Fair	Tiles	Fair	Tiles	Fair	Tiles
Player 1	0.63	0.61	0.37	0.35	0.5	0.48
Player 2	0.37	0.39	0.63	0.65	0.5	0.52

- In general, the starting player has better odds
- We expect the game to last 12-13 turns if initial states are tiles
- We expect the game to last 16 turns if initial states are fair regardless of which player begins

Code link

- https://colab.research.google.com/drive/1UbO0Hq13tfumGwsaygBs-mjdrSJSXSWF?usp=sharing