Logical Aspects of Multi-Agent Systems
Implementation of the *Cheat* game
Group 10

Rares Oancea(s3974537), Andra Minculescu(s3993507), Adrian Serbanescu(s3944735)

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1 Introduction

For the final project of the "Logical Aspects of Multi-Agent Systems" course we have decided to implement the card game known as *Cheat*.

Traditionally, the game is usually played with three or more players, and a full deck of 52 cards is used. The card is shuffled and the cards are dealt one to each player, one card to one player at a time. Once the cards have been dealt, an order is selected, either by going from left to right or anti-clockwise within the group. The first player starts by setting down one or more cards onto a common pile, and claims what are the ranks of the cards he played. The next player has to match the previous claim and place at least one card of the same rank onto the common pile. The main trick of the game is that a player can either play a card of the correct, claimed rank, play a wrong card while lying about its rank, or call another player's bluff. If the player calling the bluff proves to be correct (i.e. the previous player lied about the played rank), then the player who lied has to take the entire common pile. On the other hand, if the player who was called out played truthfully(i.e. played card(s) that match the rank stated at the beginning of the round), then the player who called a bluff has to take the pile. The game goes on in this described manner, with players placing card on the common pile and having to state each time the (alleged) rank of the played cards, the winner being the first player who gets rid of all the cards in his/her hand.

The reason why we chose this specific card game is because it displays the concept of public announcements, re-occurring in each round. More specifically, it tackles the topic of *lying in public announcements*, and since this is a very commonly played game, we have decided to implement it along with this mechanic, and observe the behaviour and performance of logical agents playing it.

2 Methods

2.1 Simplified Version of the Game

The game itself and the logical representation with Kripke models will be overly complex if we used the traditional version of the game. To this extent, in order to achieve a manageable implementation, design the logical model and focus on analyzing the logical topic we chose, we are going to implement a simplified version of the *Cheat* game.

In this version of the game, there will only be three (AI) agents that play the game. There will also be only three ranks of cards, namely Aces(A), Kings(K) and Queens(Q), and there will only be three cards of each rank in play. The types of agents will be: Trusting Agent, Distrusting Agent and Hybrid Agent. The types of agents will be explained in section 2.3.

When the game starts, a random agent is assigned to play the first hand. The game ends once an agent does not have any more cards in its hand.

Another simplification that will be made to the game revolves around how many cards an agents can play during its turn. For the traditional *Cheat* game players can play more than one card on the same turn. For the sake of simplicity however, the agents in our simulation will only be able to play one card at a time. This will also prevent the game from ending too suddenly since there are only nine cards in play.

An agent can only play a card of the correct rank (i.e. the rank declared by the agent starting the round) if it has a card with that specific rank. If this is not the case, the agent must then lie about the card it plays or call a bluff on the previous player. When an agent is caught lying about the card it played, it must then take all the cards from the common pile and the agent who called the bluff begins the next round. On the other hand, if an agent is truthful about the card it played, but another agent calls it a bluff, the agent that called the bluff must take the cards from the common pile and the agent that played the correct card begins the next turn. Another important rule is that one can only call a bluff on the previous agent that played a card.

If at any point in the game an agent has all three types of the same card (e.g. three Queens), it will then be able to discard those three cards into a separate pile. We also accounted the scenario in which, by chance, at the start of the game an agent is dealt a hand with three cards of the same type. If this ever happens, the deck is reshuffled and the hands are dealt again.

2.2 Decision Points

Throughout the simulation, the three agents will have to tackle three main decision points. All scenarios stem from the situation in which an agent has to play a card when its turn comes around. This can either happen in the middle of a round, with some cards already having been placed on the common pile, or at the start of the round when the agent places the first card for the round. The decision points can be described as follows:

1. What to do when you have the card matching the true rank?
   (a) Be truthful: agent plays the correct card.
   (b) Lie: agent plays a wrong card, while claiming he has played a card with the correct rank.
   (c) "Cheat!": agent calls a bluff on the agent who has played a card previous to him
2. What to do when you don't have the card matching the true rank?
   (a) Lie: agent plays a wrong card, while claiming he has played a card with the correct rank.
   (b) "Cheat!": agent calls a bluff on the agent who has played a card previous to him.
3. What to do when you start?
   (a) Be truthful: agent plays a card and declares the true rank of the card.
   (b) Lie: agent plays a card and declares a different rank.

2.3 Agent Types

Our simulation of the *Cheat* card game will make use of the following three agent types:

1. **Trusting Agent:**
   This agent believes all the public announcements are true, until there is a contradiction in the gathered knowledge and remaining worlds. Thus, it will only call *"Cheat"* when it encounters a contradiction. For example, if a pile of cards was announced by the other players to only contain *Aces*, but the trusting agent knows that there are only 3 *Aces* in the game, it will call *"Cheat"* based on the encountered contradiction.

2. **Distrusting Agent:**
   This agent believes that all public announcements are lies. Thus, if a player announced that it plays an *Ace*, the distrusting agent will believe that either a *King* or *Queen* was actually played. Thus, this agent is more prone to calling *"Cheat"* unless a contradiction is encountered. For example, if a player announces that it plays an *Ace* and the distrusting agent has in its hand two *Kings* and two *Queens* and believes that the remaining player has the other *King* and *Queen*, then it will believe that an *Ace* was actually played and will not call *"Cheat"*.

3. **Hybrid Agent:**
   This agent will alternate between the trusting and distrusting policies in a random manner.

2.4 Kripke Model

We are going to use a Kripke model of a simplified version of the card game "Cheat", in which we only have three players (P1, P2, and P3), one human player(P1), and two agents, which will be using the trusting(P2) and distrusting strategies(P3). We will have only three ranks in the game: King(K), Queen(Q), and Aces(A). For each rank, we will have only one card, in order to be able to model the game using a Kripke model. Let's take an example with an initial Kripke model which six initial possible states:

- S1:{(P1, A), (P2, K), (P3, Q)}
- S2:{(P1, A), (P2, Q), (P3, K)}
- S3:{(P1, K), (P2, A), (P3, Q)}
- S4:{(P1, K), (P2, Q), (P3, A)}
- S5:{(P1, Q), (P2, A), (P3, K)}
- S6:{(P1, Q), (P2, K), (P3, A)}

There will be three accessibility relations: R1(for P1), R2(for P2) and R3(for P3).

- R1: S1 and S2, S3 and S4, S5 and S6
- R2: S1 and S6, S2 and S4, S3 and S5
- R3: S1 and S3, S2 and S5, S4 and S6

For example, considering the relation for P1, if the real state of the world is S1, then from the agent's perspective, S2 could also be true(and vice versa). The reason behind this relation is that in both S1 and S2, P1 has an *Ace*, and P1 does not know which cards the other players have. Similarly, if the real state of the world is S3, P1 would also consider S4 a possibility (since P1 has a *King*in both), and if the real state is S5, P1 would consider S6 possible (since P1 has a *Queen* in both). The same reasoning applies to R2 and R3 as well from P2's and P3's perspectives respectively. The Kripke model can be seen in Figure 1.

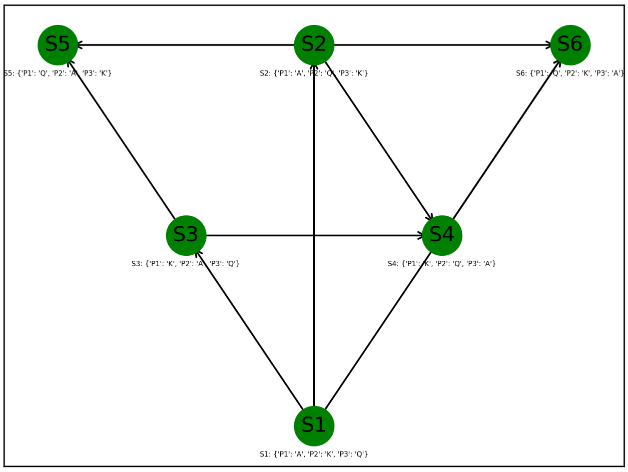

Figure 1: Graphical representation of the Kripke model with 3 players, 3 ranks and one card per rank.

Gameplay An example of a gameplay where in the end after a number of turns, there will be only one true world. (Coming soon)

3 Experiments

In order to determine which type of agent performs better in the game of *"Cheat"* we will conduct an experiment with 1000 games. We will use the simplified version of the game with a deck of 9 cards (three per rank).

4 Results

5 Discussion