# AI Agent Model Specification for Policy Negotiation in the CHALLENGE Game

**Introduction**

The CHALLENGE game, in its AI-driven iteration, aims to provide a human participant with a profound learning experience through the simulation of realistic policy negotiation concerning refugee education. At the heart of this simulation are four distinct AI agents, each designed to embody unique perspectives and engage in collaborative policymaking with the human player, who assumes the role of a parliament member in the fictional Republic of Bean. The effectiveness of this learning environment hinges on the sophistication and believability of the AI agents. This report details the comprehensive specification for the AI agent model that will power these virtual negotiators, ensuring they are engaging, realistic, and aligned with the overarching educational objectives of the game. A well-defined agent model is crucial for creating a simulation where policy discussions are nuanced, driven by diverse motivations, and ultimately lead to a deeper understanding of the complexities involved in refugee education policy. This specification covers the conceptual underpinnings of the model, the individual and collective decision-making processes of the agents, their negotiation strategies, and the mechanisms for ensuring ethical and pedagogical alignment. The subsequent sections of this report will elaborate on each of these critical aspects, providing a blueprint for the development of the AI agents.

**Conceptual Foundations**

**Swarm Intelligence and Multi-Agent Negotiation**

The design of the AI agent model for the CHALLENGE game draws inspiration from the principles of swarm intelligence, a paradigm that studies how decentralized groups of simple agents can collectively solve complex problems through local interactions.1 Natural systems such as ant colonies, bee colonies, and bird flocks exhibit remarkable coordination and problem-solving capabilities without any central control.1 Key concepts within swarm intelligence include decentralization, where no single entity dictates the behavior of the group; local interactions, where agents primarily respond to their immediate surroundings and neighbors; self-organization, where global order and functionality emerge from these local interactions without explicit top-down direction; and emergent behavior, which refers to the complex, often intelligent, collective patterns that arise from the simple rules followed by individual agents.1

In the context of the CHALLENGE game, the four AI agents and the human participant can be viewed as a multi-agent system where the final policy outcome is an emergent property of their interactions and negotiations.1 Each agent, driven by its own profile and preferences, will react to the proposals and arguments of the others, contributing to a collective decision-making process.1 This decentralized approach offers several advantages for the game, including robustness, as the system can continue to function even if one agent's viewpoint is not fully accommodated; potential scalability for future expansions involving more AI agents; and adaptability, allowing the system to respond dynamically to the human player's input.1 The negotiation process, where agents exchange arguments and make concessions, mirrors the local interactions observed in natural swarms, ultimately leading to a collectively agreed-upon policy package.

While swarm intelligence emphasizes decentralized control, the game structure, with its defined phases of individual selection, group dialogue, and voting, provides a framework for managing the communication and interaction among the agents.1 Effective communication protocols will be essential to ensure that the negotiation is coherent and productive. The final policy outcome, selected through a majority vote, represents a form of collective intelligence, where the group's aggregated preferences and compromises result in a solution that ideally reflects the diverse perspectives of the participants.4

**Agent Profiling and Utility Functions**

To ensure the AI agents represent diverse viewpoints, each agent will be defined by a unique profile consisting of five attributes: Age, Education, Occupation, Socioeconomic Status, and Political Stance [User Query]. It is crucial to note that attributes such as Race, Ethnicity, Gender, and Sexual Orientation will be explicitly excluded from the agent profiles to prevent the possibility of harmful stereotyping [User Query]. This selection of attributes aims to create relevant differences in policy preferences without relying on potentially sensitive or stereotypical categories.

The decision-making process of each AI agent will be guided by an internal utility function, a mathematical representation of the agent's preferences.16 This function will map the various policy options available in the game to numerical preference scores based on the agent's specific profile.16 A multi-attribute utility function is deemed most suitable for this model, as it allows for the evaluation of policy packages across the seven distinct policy areas: Access, Language, Teacher Training, Curriculum, Psychosocial Support, Financial Support, and Certification.18 The utility function will essentially quantify the desirability of each possible policy package for a given agent.

When faced with a decision, such as selecting an initial policy package or considering a compromise during negotiation, each AI agent will strive to choose the option that maximizes its expected utility.17 This principle of utility maximization will drive the agent's behavior throughout the game. The design of these utility functions will be theoretically grounded in the axioms of rational preferences, including orderability, transitivity, continuity, substitutability, and monotonicity, which ensure a degree of consistency and predictability in the agents' choices.23 While the model aims for rational behavior, it is acknowledged that human preferences can sometimes deviate from perfect rationality.23 The mapping from agent profiles to utility functions might incorporate subtle nuances to reflect real-world inconsistencies, but these should be carefully managed to maintain the integrity of the negotiation logic.

**Phase I: Individual Policy Preference Formation**

**Developing Algorithms for Initial Policy Package Selection**

In the first phase of the game, each of the four AI agents will independently select an initial policy package. This selection process will be governed by an algorithm designed to maximize the agent's internal utility while strictly adhering to the game's constraints, namely the total budget of 14 units and the requirement for a mix of policy option tiers [User Query]. Given that there are seven policy areas, each with three possible options (costing 1, 2, or 3 units respectively), the algorithm will need to evaluate a significant number of potential policy package combinations.

The algorithm will systematically iterate through all possible combinations of policy options across the seven areas. For each combination, it will first calculate the total cost by summing the costs associated with the selected option in each area. Packages exceeding the 14-unit budget will be deemed invalid and discarded. For those packages that fall within the budget, the algorithm will then check if the requirement for a mix of option tiers is met. This will involve counting the number of Option 1, Option 2, and Option 3 choices within the package. If all seven selected options belong to the same tier, the package will also be considered invalid.

For each policy package that satisfies both the budget and the tier mix constraints, the agent's individual utility function will be applied to calculate a utility score. This score will reflect how well the specific combination of policy options aligns with the agent's preferences as determined by its profile. After evaluating all valid policy packages, the agent will select the package that yields the highest utility score as its initial preferred policy package for the subsequent negotiation phase. While the number of combinations is manageable for direct evaluation, for potential future expansions or more complex scenarios, techniques such as constraint programming could offer a more efficient approach to finding the optimal solution under the given constraints.25

**Mapping Profile Attributes to Policy Preferences**

The core of the AI agents' diverse perspectives lies in the mapping of their profile attributes to specific policy preferences. This mapping dictates how an agent's age, education, occupation, socioeconomic status, and political stance influence its initial inclinations towards the different policy options within each of the seven areas. The following examples illustrate potential relationships:

An older agent (Age: 60+) with a High School Diploma (Education), having worked as a Factory Worker (Occupation) from a Working Class background (Socioeconomic Status), and holding a conservative political stance might prioritize basic access (Option 1, cost: 1 unit), language training focused on basic communication skills (Option 1, cost: 1 unit), minimal teacher training requirements (Option 1, cost: 1 unit), a curriculum centered on essential skills for immediate employment (Option 1, cost: 1 unit), limited psychosocial support (Option 1, cost: 1 unit), minimal direct financial support to refugees (Option 1, cost: 1 unit), and a certification process focused on immediate job readiness (Option 1, cost: 1 unit). This agent's preferences reflect a focus on fiscal responsibility and the swift integration of refugees into the workforce with minimal public expenditure.

Conversely, a younger agent (Age: 25-35) with a Master's Degree (Education), working as a Social Worker (Occupation) from a Middle Class background (Socioeconomic Status), and holding a liberal political stance might favor comprehensive access to education for all refugees (Option 3, cost: 3 units), bilingual education programs (Option 3, cost: 3 units), extensive teacher training on trauma-informed practices and cultural sensitivity (Option 3, cost: 3 units), a broad curriculum encompassing cultural integration and critical thinking (Option 3, cost: 3 units), comprehensive psychosocial support services (Option 3, cost: 3 units), substantial financial support including stipends for families (Option 3, cost: 3 units), and a certification system recognized for further educational pursuits and professional advancement (Option 3, cost: 3 units). This agent's preferences emphasize social justice, inclusivity, and holistic support for refugees' long-term well-being and integration.

An agent with a moderate political stance might select a mix of Option 1, 2, and 3 choices across the seven policy areas, seeking a balance between different priorities and budgetary considerations. The "Political Stance" attribute will be particularly influential in shaping preferences related to the scope of inclusion, the approach to language policy (assimilation vs. multiculturalism), and the goals of certification (immediate employment vs. long-term development). These mappings are designed to generate diverse and plausible viewpoints among the four AI agents, ensuring a rich and engaging negotiation dynamic. It is crucial to avoid relying on harmful stereotypes when defining these relationships, ensuring that the profiles represent realistic perspectives without resorting to prejudiced assumptions.27 Research on how personality traits can influence policy preferences 28 informs the design of these mappings, suggesting that even abstract attributes can be linked to predictable decision-making patterns.

**Phase II: Collaborative Policy Negotiation**

**Designing the Negotiation Logic**

The second phase of the game involves a voice-based negotiation between the four AI agents and the human participant. To facilitate this interaction, clear communication protocols will be established, allowing for turn-taking, the ability to ask clarifying questions, and structured mechanisms for proposing and responding to policy options.8 At the outset of the negotiation, each AI agent will present its individually selected initial policy package, clearly articulating the reasons behind its choices. This justification will explicitly link the chosen options back to the agent's profile attributes and the perceived advantages and disadvantages associated with those options.10 For instance, an agent might state, "Given my background as a factory worker, I believe a curriculum focused on practical skills (Option 1) is the most beneficial for refugees seeking employment."

The negotiation will largely follow an argumentation-based approach, where agents will not only present their preferred options but also provide reasons and justifications to support their proposals.10 They will be able to construct arguments based on their profile-driven priorities and the information provided about the pros and cons of each policy option. This framework allows for a more nuanced and reasoned discussion compared to simple offer-counteroffer exchanges.

**Adaptive Argumentation and Response Strategies**

A key aspect of realistic negotiation is the ability to adapt one's stance based on the arguments and proposals of others. The AI agents in the CHALLENGE game will be designed with this capability. They will process and attempt to understand the arguments presented by the human player and the other AI agents, likely utilizing natural language processing techniques to analyze the content and intent of these arguments.35 Each agent will then evaluate the validity and relevance of these arguments in relation to its own utility and overarching goals. An argument that directly challenges a policy option strongly preferred due to a core profile attribute might be scrutinized more closely.

Based on this evaluation, the AI agents will be able to adapt their negotiation stances. This could involve modifying their preferred policy options in certain areas, proposing alternative solutions, or formulating counter-arguments to challenge the viewpoints of others.10 This adaptation will not be arbitrary but will be guided by the agent's desire to maximize its utility within the context of the ongoing discussion and the perceived likelihood of reaching a mutually acceptable agreement. Elements of anticipating future conversation directions, similar to "dialog rollouts," might be incorporated, where an agent strategically concedes on a less important issue to gain leverage on a more critical one.38 Furthermore, the agents might engage in a form of argumentative refinement, where they challenge each other's reasoning to arrive at more robust policy proposals.39

**Strategic Compromise and Game Theory**

The negotiation process will also incorporate principles from game theory, particularly the concept of strategic compromise, with agents implicitly aiming for outcomes aligned with their profiles while considering the preferences of the other participants. While the game does not explicitly require the agents to calculate a formal Nash Equilibrium, their behavior will reflect a similar underlying logic. Nash Equilibrium, in game theory, describes a state where no player can improve their outcome by unilaterally changing their strategy, assuming the other players' strategies remain constant.42 In the context of the game, each AI agent will internally model the potential preferences and actions of the other agents and the human player. This internal model will inform their adjustments to offers and demands, with the goal of reaching a final policy package that maximizes their utility given the likely outcomes of the negotiation.50

Achieving a perfect Nash Equilibrium in a dynamic negotiation involving a human participant can be challenging, as human behavior is not always perfectly rational or predictable.43 However, the AI agents will strive for strategically advantageous compromises. This means they will be more willing to make concessions on policy areas that are less critical to their profile-driven utility in order to gain agreement on areas they prioritize more highly.53 For example, an agent with a strong preference for comprehensive language training (driven by its profile) might be more flexible on the level of financial support offered, recognizing that securing their preferred language policy outcome might require concessions elsewhere. This strategic balancing of priorities and willingness to compromise is essential for the AI agents to effectively participate in the collaborative policymaking process.

**Phase III: Collective Decision and Voting**

**Implementing the Voting Mechanism**

Following the negotiation phase, the final policy package will be determined through a majority vote. Each of the five participants – the four AI agents and the human player – will submit their vote for their preferred comprehensive policy package, which consists of one option selected from each of the seven policy areas. The AI moderator will then tally these votes to determine the winning policy package. Based on a total of five votes, a simple majority of three votes will be required for a policy package to be adopted as the final outcome of the simulation.

**Tie-Breaking Strategies**

In the event of a tie in the voting process, where no single policy package receives a clear majority (e.g., two packages each receive two votes, with one vote for a third), a pre-defined tie-breaking strategy will be implemented by the AI moderator.55 One potential tie-breaking mechanism could involve the AI moderator having a pre-defined fallback policy package that represents a neutral or compromise-oriented solution. If a tie occurs, the moderator could select this pre-determined package as the final outcome. Alternatively, a random selection from among the tied policy packages could be used to ensure fairness. The justification for the chosen tie-breaking strategy will consider both fairness and its potential impact on the learning experience for the human participant. A compromise solution might be more pedagogically valuable as it reinforces the idea that policy decisions often involve finding common ground.

**Ensuring Constraint Compliance**

Once the voting process is complete and a final policy package has been selected (either by majority vote or through the tie-breaking mechanism), the AI moderator will perform a final check to ensure that this package adheres to the fundamental game constraints [User Query]. First, the moderator will calculate the total cost of the selected policy options across the seven areas to verify that it does not exceed the total budget of 14 units. Second, the moderator will examine the tiers of the selected options to confirm that the final policy package includes a mix of Option 1, Option 2, and Option 3 choices, and does not consist solely of options from a single tier. If the voted policy package violates either of these constraints, the AI moderator will need to take appropriate action. This could involve announcing the violation to the participants and requiring a revote, prompting further negotiation to arrive at a compliant package, or, in more structured scenarios, the moderator might impose a slightly modified version of the most popular package that satisfies the constraints while remaining as close as possible to the majority preference.

**Ethical and Pedagogical Alignment in Agent Behavior**

**Strategies for Promoting Justice, Inclusion, and Refugee Rights**

The design of the AI agents and their interactions within the CHALLENGE game will actively promote the values of justice, inclusion, and refugee rights [User Query]. The agent profiles and their corresponding policy preferences will be carefully crafted to represent a spectrum of perspectives on refugee education, with some agents strongly advocating for policies that uphold these ethical principles. This diversity of viewpoints is intended to foster empathy and a deeper understanding of the various considerations involved in policymaking for the human player. The negotiation dialogue will be designed to naturally incorporate arguments and justifications that highlight the importance of justice, inclusion, and refugee rights. For example, an agent with a liberal political stance might articulate arguments based on the fundamental right to education for all individuals, regardless of their refugee status. Furthermore, the AI agents might introduce information about the potential long-term benefits of inclusive refugee education policies for both the refugees and the host society.

**Avoiding Harmful Stereotypes and Anti-Migrant Narratives**

Preventing the emergence of harmful stereotypes and anti-migrant narratives in the AI agents' behavior and communication is of paramount importance [User Query]. As previously mentioned, the exclusion of sensitive demographic attributes like race, ethnicity, gender, and sexual orientation from the agent profiles is a primary strategy to mitigate the risk of stereotyping. Additionally, strict guidelines will be established to govern the language and arguments that AI agents can employ during the negotiation. These guidelines will explicitly prohibit the use of harmful stereotypes, prejudiced language, or anti-migrant sentiments.27 The agents' knowledge base and dialogue generation capabilities will be carefully curated to ensure ethical and responsible communication. A content filtering mechanism might be implemented to detect and prevent the expression of biased or harmful content. Regular monitoring and testing of the AI agents' dialogue will be essential to identify and address any unintended biases that may arise. The design will also prioritize the pedagogical goals of reflection and critical thinking over a purely competitive negotiation dynamic [User Query]. The AI agents should encourage the human participant to critically examine the different policy options and their implications, rather than simply trying to dominate the discussion or impose their own preferred outcome. This multi-faceted approach aims to create a learning environment that is both informative and ethically sound.

**Conclusion**

This detailed specification outlines the design for an AI agent model intended to power realistic policy negotiation within the AI-driven CHALLENGE game. The model incorporates principles of swarm intelligence to inform the multi-agent interaction, utilizes utility functions to represent diverse policy preferences derived from agent profiles, and implements a structured approach to individual preference formation, collaborative negotiation, and collective decision-making through voting. The negotiation phase is designed to be adaptive and strategic, drawing inspiration from game theory principles to encourage compromise and reasoned argumentation. Furthermore, the specification emphasizes the critical importance of ethical and pedagogical alignment, detailing strategies to promote values of justice and inclusion while actively preventing harmful stereotypes and anti-migrant narratives. By adhering to these specifications, the AI agents in the CHALLENGE game have the potential to create a realistic and engaging simulation that fosters critical thinking, empathy, and a deeper understanding of the complexities inherent in refugee education policymaking for the human participant. Future development could explore more advanced negotiation strategies, finer-grained agent profiles, and mechanisms for incorporating real-world data to further enhance the richness and realism of the simulation.

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