Multi-Deal Hybrid Agent: A Concession-Based Negotiator for Multi-Party Coordination

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Abstract

This report presents the **Multi-Deal Hybrid Agent**, a negotiation agent designed for the ANAC 2025 challenge. Building upon hybrid time- and behavior-based strategies [3], the agent is adapted for sequential multi-deal settings by dynamically modulating concession parameters across subnegotiations. It maintains effective utility trade-offs while addressing the challenges of forward-planning across multiple dependent deals.

1 Problem Definition

ANAC 2025 introduces a complex negotiation setting: a center agent engages in sequential negotiations with multiple edge agents, where the utility of the final outcome depends on the combination of all individual agreements [2]. The primary difficulty lies in balancing current negotiation performance with the anticipated outcomes of future ones, all under private preference profiles and varying negotiation contexts. Early concessions may preclude better future deals, while excessive stubbornness risks ending without agreement.

2 Proposed Solution

The **Multi-Deal Hybrid Agent** extends the utility-based strategy of [3] by adjusting target utilities across sequential deals. The main enhancements include dynamic concession control, adaptive opponent mimicry, and strategic acceptance.

2.1 Coordination Across Subnegotiations

To handle the sequential multi-deal format, the agent adapts its concession depth p_2 for each subnegotiation index i out of n total:

$$p_2 \leftarrow p_2 - \min(0.2, (i/n)^2 \cdot 0.2) \tag{1}$$

This decaying adjustment prevents over-commitment early in the sequence and increases flexibility in later negotiations.

2.2 Bidding Strategy

The agent calculates its target utility using a hybrid of time- and behavior-based functions:

$$TU_{hybrid}(t) = (1 - t^2) \cdot TU_{behavior}(t) + t^2 \cdot TU_{time}(t) \tag{2}$$

Time-Based Utility uses a quadratic Bézier curve:

$$TU_{time}(t) = (1-t)^2 p_0 + 2(1-t)tp_1 + t^2 p_2 \tag{3}$$

- p_0: Initial utility demand (typically set to the best offer's utility)

- p_1: Curvature control (moderate concession)
- p_2: Minimum acceptable utility, modulated by subnegotiation index

Behavior-Based Utility adapts based on opponent concession patterns:

$$\Delta U = \sum_{i=1}^{n} W_i \cdot (U(o_{t-i}) - U(o_{t-i-1})) \tag{4}$$

$$\mu = p_3(1+t) \tag{5}$$

$$TU_{behavior}(t) = U_{last} - \mu \cdot \Delta U \tag{6}$$

- μ: Adaptive mimic factor; increases over time via p_3
- W_i: Weights to emphasize recent opponent bids
- $U(o)$: Utility of offer o in current negotiation context

Bids are selected from offers satisfying $|U(b) - TU_{hybrid}(t)| \leq \epsilon$, with preference for the closest.

2.3 Acceptance Strategy

Inspired by ACNext [1], the agent adopts a threshold-based policy:

$$\text{Accept if } U_{offer} \geq \theta(t) \tag{7}$$

$\theta(t)$ is a monotonically decreasing threshold that mirrors the agent's own willingness to concede. This ensures rational acceptance of mutually beneficial offers without preemptively terminating high-value opportunities.

3 Conclusion

The Multi-Deal Hybrid Agent advances the hybrid utility framework by integrating dynamic subnegotiation-aware concessions, opponent-adaptive mimicry, and strategic offer acceptance. It directly addresses the core challenge of ANAC 2025: reasoning under uncertainty across a sequence of interdependent deals.

References

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