

Adaptive Truthfulness: Randomized Shading Across the Game Horizon



Algorithm Description (Final Agent)

Our final agent is a **budget-feasible, value-proportional bidder** that follows a *truthful baseline* (bid near its private valuation) while applying **time-varying random shading**.

For each item, the agent computes:

- **Base bid:** $b = v \cdot m_r$
where v is our valuation for the current item and m_r is a random multiplier that depends on the round index r .
- **Round-dependent shading schedule (piecewise):**
 - **Rounds 0–5:** stronger conservative shading (lower multiplier range)
 - **Rounds 6–10:** moderate shading
 - **Rounds 11–14:** more aggressive shading (multiplier closer to 1)

This schedule is implemented with `rand_multiplier()` using `rounds_completed` as the game clock.

Finally, the bid is **always capped by remaining budget** with a small numerical epsilon to avoid engine cap warnings:

- $b \leftarrow \min(b, \text{budget} - \epsilon)$

This makes the strategy robust: it never submits infeasible bids, avoids floating-point edge cases, and remains simple and stable across many randomized simulations.



Reasoning Process and Design Rationale

We started with the idea that a more “sophisticated” strategy (Bayesian inference + shadow prices / λ -based pacing) would outperform simple baselines. In practice, **simulation results showed a clear and repeatable advantage for near-truthful behavior**: agents that bid close to their valuations consistently achieved strong utility across seeds and game instances. This was a key insight: the environment behaves like a repeated second-price setting where **overcomplicating the model can introduce instability** and reduce performance.

From there, our goal shifted from “outsmarting the auction theory” to **beating the strongest empirical baseline: truthful-style bidders**.

Key insights we used

1. **Truthful bidders are strong but exploitable through budget dynamics.**
Even if bidding truthfully is dominant in a single Vickrey auction, here we have a *sequence* of auctions with a binding budget. A truthful bidder tends to **overspend early on items that are “good for everyone”** (high common value), which can drain their budget and reduce their ability to compete later.
2. **We want asymmetric wins:**
 - **Avoid paying too much** on items that are likely valuable to everyone (because competition is fierce and the second price becomes expensive).
 - **Win items that are high for us** when opponents are budget-constrained or when competition is weaker.
3. **Endgame matters: unused budget is wasted.**
In repeated auctions, finishing with money left is a missed opportunity. At the same time, burning budget too early increases exposure to high second-prices