Temasek Defence Systems Institute

Investigating Hybrid Time Management for Mixed TAR and NER Federates in HLA-based Distributed Simulations

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Background

Distributed simulations built on the High-Level Architecture (HLA) face challenges when federates must combine predictable periodic behaviors with rapid responsiveness to asynchronous events. Traditional Time Advance Request (TAR) ensures strict timing, while Next Event Request (NER) allows reactivity. However, current HLA federates must choose one mode at startup, preventing adaptive behaviors needed in modern, human-in-the-loop systems.

Research Objectives

- Design a simulation framework enabling runtime switching between TAR and NER modes.
- Implement the framework using the Portico RTI's restaurant simulation.
- Evaluate synchronization integrity, latency, and event ordering.
- Identify constraints in current RTI implementations affecting hybrid time management.

Methodology

The study extends the Portico "Restaurant" simulation, where a waiter federate must serve drinks every 5 seconds while reacting instantly to customer arrivals.

Five approaches were tested:

- Pure TAR: Fixed periodicity.
- Pure NER: Fully event-driven.
- Interruptible TAR: Attempted mid-advance cancellation (failed).
- Hybrid A: TAR with delayed in-wait reactions.
- Hybrid B: NER with TAR catch-up (proposed adaptive model).

Key metrics: cadence accuracy, reaction latency, and causality safety.

Results

Approach	Cadence Accuracy	Reaction Latency	Causality Safety	Comments
TAR	Perfect	High	Safe	Rigid. No responsiveness
NER	Poor	Very Low	Safe	Drifts over time
Hybrid A	Perfect	Moderate	Safe	Bounded delay (5s)
Hybrid B	**Perfect**	**Low**	**Safe**	**Best balance**

Discussion

- Pure TAR: reliable but non-reactive.
- Pure NER: reactive but imprecise timing.
- Hybrid B (NER + TAR catch-up): achieves both periodicity and responsiveness using only existing HLA services.
- No RTI modification required—maintains full IEEE 1516 compliance.

Conclusions

- Adaptive hybrid time management is feasible within conservative HLA synchronization rules.
- Hybrid B demonstrates that alternating between NER and TAR each cycle allows low latency, zero cadence drift, and causality preservation.

Future Work

- Explore adaptive lookahead and lock policies.
- Expand to multi-federate hybrid systems.

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