

THE ATHENIAN ACADEMY: A SEVEN-LAYER ARCHITECTURE FOR MULTI-AGENT SYSTEMS

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ABSTRACT

This paper introduces the Athenian Academy, a novel seven-layer architecture for Multi-Agent Systems (MAS) designed to address the fragmented and ad-hoc approaches prevalent in current system design. Our framework moves the field towards principled and reproducible engineering by systematically decomposing complex agent interactions into seven distinct, analyzable layers. Through a series of quantitative experiments, grounded in the challenging domain of AI-driven artistic creation, we empirically validate the efficacy of each layer. Our results demonstrate significant improvements over baseline approaches in key metrics such as collaborative efficiency, thematic consistency, and cross-domain knowledge transfer. Ultimately, the Athenian Academy offers a structured and validated methodology for designing, analyzing, and building the next generation of sophisticated, collaborative, and responsible AI systems.

1 INTRODUCTION

Inspired by the collaborative ethos of Raphael’s fresco, “The School of Athens,” we propose a structured approach for designing and understanding modern Multi-Agent Systems (MAS). The recent proliferation of LLM-based agents has led to a Cambrian explosion of ad-hoc system designs, often assembled without a guiding framework. This practice creates a critical research gap, leading to significant challenges in reproducibility, comparison, and systematic advancement. Systems are frequently built as monolithic black boxes or tangled webs of API calls, making it difficult to attribute successes or failures to specific design choices. The cost of such ad-hoc design is substantial, resulting in wasted computational resources on brittle, non-deterministic systems and making rigorous ablation studies nearly impossible. Current MAS design often resembles building complex structures without the foundational principles of civil engineering or software architecture; the results can be impressive but are often brittle, unpredictable, and difficult to analyze, scale, or maintain.

To address this gap, we introduce the *Athenian Academy Architecture*, a seven-layer framework that serves as both a design pattern and a taxonomy for classifying agent capabilities. This layered abstraction, analogous to the OSI model in computer networking, decomposes the complexity of multi-agent collaboration into manageable, well-defined problems. To our knowledge, this is the first work to propose such a comprehensive, multi-dimensional taxonomy for LLM-based agent architectures. Our main contributions are:

- A novel seven-layer architecture that provides a structured vocabulary and a set of design principles for designing and analyzing MAS, moving the field from ad-hoc construction to principled engineering.
- A series of quantitative experiments that empirically validate the benefits of each architectural layer against well-defined baselines in the challenging domain of AI art creation, demonstrating the concrete value of this structured approach.
- An in-depth analysis of the underlying mechanisms that drive the observed performance improvements, linking architectural choices to specific outcomes like mitigating mode collapse, preventing knowledge contamination, and enhancing cognitive transfer.

Our work is situated at the intersection of MAS and AI-driven art creation—a domain that serves as a particularly challenging testbed for general MAS capabilities. Its requirements for subjectivity,



Figure 1: Raphael’s *The School of Athens*, a metaphor for intellectual collaboration that inspires our architectural philosophy.

ambiguity, creativity, and multi-modal synthesis push beyond the limits of purely logical or objective problem domains, thereby stress-testing the architecture’s ability to handle complex, ill-defined problems that are hallmarks of real-world interaction.

2 RELATED WORK

In recent years, significant progress has been made in intelligent agent systems based on large language models (LLMs). Early works primarily focused on single-agent systems, enhancing core competencies like task decomposition (L., 2023), multi-path thinking such as in Tree-of-Thought approaches (KHOT T., 2023; YAO S., 2023), and learning from past experiences through reflection mechanisms (SHINN N., 2023). Moreover, single-agent systems have also shown promising results in tool usage (LI M., 2023; RUAN J., 2023) and the integration of sophisticated memory mechanisms (GAO Y., 2023). These efforts laid the groundwork by establishing the fundamental cognitive capabilities of an individual LLM-based agent.

However, the focus of single-agent systems on internal mechanisms limits their application in complex, multi-faceted problems that inherently require diverse perspectives and skills. To address this, researchers have begun to explore multi-agent systems (MAS) based on LLMs, where specialized agents collaborate to achieve “collective intelligence.” This approach has been applied to diverse fields. In software development, systems like ChatDev and MetaGPT automate the entire process from requirement analysis to testing (HONG S., 2023; QIAN C., 2024). In multi-robot systems, collaboration improves robustness and efficiency in physical environments (MANDI Z., 2024; ZHANG H., 2024). In social and policy simulation, MAS model complex emergent behaviors and societal dynamics (PARK J S., 2023; XIAO B., 2023; HUA W., 2024), and in game simulation, they exhibit flexible interaction strategies and human-like emergent behaviors (XU Z., 2024; WANG L., 2024).

Despite these advances, a significant gap persists. Most existing MAS are task-specific solutions, constructed with ad-hoc combinations of roles and communication protocols. They demonstrate that collaboration works, but provide little guidance on how to systematically design for it. Their architectures are often implicit and entangled with the specific application logic. Frameworks like the Belief-Desire-Intention (BDI) model have long provided structure for symbolic agents, but a new paradigm is needed to fully harness the probabilistic and generative nature of LLMs. Our work addresses this gap directly by proposing a foundational architectural framework that provides a structured vocabulary and a set of design principles for building sophisticated MAS in a systematic and reproducible manner.

3 THE ATHENIAN ACADEMY ARCHITECTURE

We propose the *Athenian Academy* seven-layer architecture as a systematic framework for designing and analyzing MAS. These layers are a conceptual model representing an increasing order of complexity and integration, analogous to building a sophisticated organization from individuals to teams to the entire enterprise. It provides a clear path for scaling system capabilities from simple interactions to complex, synthesized intelligence.

The architecture’s seven layers follow a deliberate progression from the micro-level of agent interaction to the macro-level of system synthesis. We begin with the fundamentals of *inter-agent dynamics* (Layer 1), establishing the “social contract” of how agents interact, which forms the bedrock of any collaborative effort. We then explore the richness of *intra-agent adaptability* (Layers 2-4), defining an individual agent’s capabilities—from being a multi-faceted role-player to a cross-domain learner to a manager of specialized skills. This is akin to defining the roles, expertise, and growth potential of individuals within an organization. Next, we address advanced *agent-model interaction patterns* (Layers 5-6), examining the “infrastructure” agents use to leverage the power of large models, either collectively through a shared resource or by orchestrating multiple specialized models. This corresponds to providing the organization with shared tools and specialized equipment. Finally, the framework culminates in holistic *agent-system synthesis* (Layer 7), representing the “board of directors”—a unified intelligence that is greater than the sum of its parts, capable of making complex, arbitrated decisions to align the entire system toward a common goal.



Figure 2: The Athenian Academy seven-layer architecture.

3.1 LAYER 1: MULTI-AGENT COLLABORATION

Concept and Motivation. This foundational layer concerns the direct interaction of multiple autonomous agents, each with its own distinct context and conversational history. The primary challenge it addresses is the phenomenon of *mode collapse* or the “echo chamber” effect inherent in single, monolithic LLM instances. When a single model is prompted to simulate a debate, its internal representations tend to converge on a single, high-probability mode of thinking, as the attention mechanism naturally seeks to create a coherent, unified narrative. This layer posits that architectural separation of agents is a necessary regularizer to foster genuine intellectual diversity,

Dimension	Definition	Athenian (Multi-Agent)	Baseline (Single Agent)
Critical Depth	A 1-5 expert rating of the discourse’s complexity, nuance, and integration of multiple viewpoints.	4.3 ± 0.4	2.8 ± 0.6
Human Expert Rating	An overall 1-5 expert rating of the output’s creativity and philosophical insight.	4.1 ± 0.5	3.0 ± 0.7
Collaboration Fluency	A 1-5 rating of the smoothness of turn-taking and relevance of responses in the dialogue flow.	4.5 ± 0.3	N/A

Table 1: Results for Layer 1 Validation: Multi-Agent Collaboration.

Dimension	Definition	Athenian (Multi-Role)	Baseline (Monolithic)
Role Consistency	A 1-5 expert rating of how well the agent maintains a consistent persona for each role.	4.6 ± 0.3	2.5 ± 0.7
Knowledge Contamination Rate	Percentage of responses where the agent incorrectly uses knowledge or style from an inactive role.	$4\% \pm 2\%$	$35\% \pm 10\%$
Switching Fluency	A 1-5 rating of the naturalness and coherence of transitions between roles.	4.4 ± 0.4	2.8 ± 0.6

Table 2: Results for Layer 2 Validation: Single-Agent Multi-Role Playing.

forcing the model to explore disparate parts of its latent space, analogous to how diverse teams in human organizations prevent groupthink.



Figure 3: A Multi-Agent Collaborative Creation Framework.

Validation. We simulated a philosophical debate on the nature of justice with three agents instantiated with the personas of Aristotle, Plato, and Socrates, using GPT-4 as the backbone for each. The baseline was a single agent (also GPT-4) tasked with simulating all three roles within a single prompt and context window. The experimental setup involved five runs for each condition, with expert ratings provided by two graduate students in philosophy on a 1-5 Likert scale based on a pre-defined rubric assessing argumentation, novelty, and persona adherence.

Results and Analysis. Table 1 shows the multi-agent configuration yielded a discourse of significantly higher critical depth (4.3 vs. 2.8). The architectural separation into distinct agent contexts forces the

Dimension	Definition	Athenian (Traversal)	Baseline (Separate)
Cognitive Flexibility	The number of times the agent generated a novel solution or analogy based on cross-scene experience.	3.5 ± 0.8	1.2 ± 0.5
Positive Transfer Rate	Percentage of cross-scene knowledge applications that were deemed relevant and helpful by experts.	$68\% \pm 11\%$	N/A
Evolution Quantifiability	The percentage improvement in task performance metrics upon returning to the original scene.	$15\% \pm 4\%$	$2\% \pm 1\%$

Table 3: Results for Layer 3 Validation: Single-Agent Cross-Scene Experience Traversal.

Dimension	Definition	Athenian (Avatars)	Baseline (Monolithic)
Expertise Depth	A 1-5 expert rating of the technical correctness and sophistication of domain-specific outputs.	4.4 ± 0.4	2.9 ± 0.6
Collaboration Efficiency (min)	Total time in minutes to complete the entire multi-faceted project.	8 ± 2	20 ± 5
Style Consistency	A 1-5 rating of the thematic and stylistic unity across outputs from different avatars.	4.2 ± 0.5	3.8 ± 0.4

Table 4: Results for Layer 4 Validation: Single-Agent Multi-Capability Avatars.

underlying LLM to maintain separate, parallel reasoning threads. This acts as a powerful regularizer against the model’s natural tendency to find the “average” or most probable response, which in the baseline case led to a premature and superficial consensus. The distinct contexts compel the model to explore different parts of its vast parameter space for each persona, resulting in a more genuinely dialectical interaction that mirrors true intellectual debate.

3.2 LAYER 2: SINGLE-AGENT MULTI-ROLE PLAYING

Concept and Motivation. This layer explores an agent’s ability to embody multiple, distinct roles sequentially. The core challenge, from a cognitive science perspective, is preventing *catastrophic forgetting* or *knowledge and style contamination* between roles. Without explicit separation, an LLM’s attention mechanism can “bleed” information across conceptually distinct personas within the same context. This layer’s architectural solution is to use an explicit finite state machine to create “firewalls” between persona contexts. Each state corresponds to a role, and transitions involve programmatically swapping not just the system prompt but also the relevant short-term memory buffer, ensuring role integrity through contextual isolation.

Validation. An agent was designed to switch between three artist personas: a classical painter, a modernist sculptor, and a digital artist. The baseline was a monolithic agent given all persona information in one unstructured prompt, asked to switch roles upon command. Role consistency was evaluated by experts checking for adherence to the persona’s known style and historical context. The knowledge contamination rate was measured by counting instances where, for example, the ‘classical painter’ persona referred to digital art concepts.

Results and Analysis. The multi-role agent with the state machine architecture excelled at maintaining distinct personas (Table 2). The dramatically lower knowledge contamination rate (4% vs. 35%) provides strong evidence that the state-based context switching mechanism is effective. This explicit state management acts as a powerful safeguard against the natural tendency of LLMs to blend concepts within a single, continuous context. It ensures each persona operates from a clean, isolated knowledge base, thereby preserving the integrity of each specialized role.

Dimension	Definition	Athenian (Shared)	Baseline (Separate)
Output Cohesion	A 1-5 expert rating of the stylistic and thematic consistency of the final artwork.	4.7 ± 0.2	2.1 ± 0.8
Information Flow	Percentage of critical information (e.g., masks, color palettes) successfully transferred between agents.	$98\% \pm 2\%$	$55\% \pm 15\%$
Collaboration Efficiency (min)	Total time in minutes to complete the project.	11 ± 3	20 ± 4

Table 5: Results for Layer 5 Validation: Collaboration via a Shared Large Model.

3.3 LAYER 3: SINGLE-AGENT CROSS-SCENE EXPERIENCE TRAVERSAL

Concept and Motivation. This layer tests an agent’s ability to transfer and apply knowledge gained in one task environment (a “scene”) to another, structurally different one. The challenge is to achieve genuine *cognitive transfer*, a hallmark of higher intelligence, rather than simply recalling facts. This requires a persistent, structured, cross-scene memory architecture that allows the agent to form abstract connections and analogies. Our implementation uses a vector database to store summaries of key insights from each scene, indexed with metadata (e.g., domain, task type). When entering a new scene, the agent performs a semantic search on this memory to retrieve potentially relevant past experiences.

Validation. An agent was tasked to first participate in a philosophical debate (Scene A), then solve a murder mystery (Scene B), and finally return to the philosophical debate (Scene A’). The agent’s ability to apply logical frameworks from Scene A to evidence analysis in Scene B, and then use insights about human motivation from Scene B to enrich the subsequent debate in Scene A’, was measured. The baseline consisted of two separate, siloed agents with no shared memory.

Results and Analysis. The traversal agent demonstrated significant cognitive transfer (Table 3). The high positive transfer rate (68%) shows that the agent was actively synthesizing experiences. This outcome is a direct consequence of the persistent, structured memory architecture. It allowed the agent to abstract general principles (e.g., Aristotelian logic) from the philosophical scene and apply them to a new domain (e.g., evaluating witness testimonies), leading to novel insights. The 15% performance improvement upon return indicates a genuine learning effect, moving beyond simple task completion to system-level growth.

3.4 LAYER 4: SINGLE-AGENT MULTI-CAPABILITY AVATARS

Concept and Motivation. This layer explores a single agent manifesting multiple specialized “avatars.” The core challenge is that general-purpose LLMs are not universally capable, especially for tasks requiring non-linguistic, verifiable expertise. This layer proposes a controller-avatar pattern, akin to a microservices architecture in software engineering. A primary “controller” agent decomposes a problem and delegates specific tasks to specialized avatars that wrap external tools or APIs. This embodies a principle of composition over monolithic design, leveraging the LLM for reasoning and planning while relying on deterministic tools for execution.

Validation. A primary agent was tasked to create a multi-faceted art installation. It coordinated three avatars: a ‘Painting Avatar’ (interfacing with a generative art model), an ‘Engineering Avatar’ (interfacing with a physics simulator to check structural integrity), and a ‘Music Avatar’ (interfacing with a music generation API). The baseline was a single, general-purpose agent (GPT-4V) attempting to reason through and describe how to perform all tasks without specialized tools.

Results and Analysis. The avatar architecture excelled in tasks requiring specialized, non-linguistic knowledge (Table 4). The high expertise depth score (4.4 vs. 2.9) demonstrates that for complex, multi-modal problems, an architecture that integrates verifiable tools is fundamentally more capable than a monolithic model attempting to approximate those skills. It allows the system to leverage best-in-class tools for specific sub-problems, while using the LLM for its core strength: reasoning,

Dimension	Definition	Athenian (Multi-Model)	Baseline (Single Model)
Cross-Model Stylistic Coherence	A 1-5 expert rating of how well the final unified artwork blends the styles from different models.	4.3 ± 0.5	2.5 ± 0.7
Decision Diversity	A 1-5 rating of the system’s ability to generate outputs with distinct, varied styles appropriate to sub-tasks.	4.1 ± 0.6	1.0 ± 0.0
Task-Model Fit	Expert rating on how appropriately the chosen model’s strengths align with the sub-task’s requirements.	4.5 ± 0.3	3.0 ± 0.5

Table 6: Results for Layer 6 Validation: Leveraging Multiple Large Models.

planning, and coordination. The significant improvement in efficiency (8 vs. 20 minutes) highlights the value of this delegation.

3.5 LAYER 5: MULTI-AGENT COLLABORATION VIA A SHARED LARGE MODEL

Concept and Motivation. This layer involves multiple agents utilizing the same foundational model instance and a shared memory bus. The key challenge in multi-agent creation is that when agents use different generative models, their outputs often have incompatible stylistic biases and semantic representations due to differences in their latent spaces. This layer’s solution is to enforce *stylistic and semantic consistency* by anchoring all agents to a single foundational model. This ensures all operations occur within the same latent space. The shared memory bus is not just a message queue but a structured “blackboard” system where agents can post and retrieve complex data objects (e.g., images, masks, color palettes) directly, avoiding the information loss inherent in natural language communication.

Validation. Three agents (a ‘Concept Artist’, a ‘Detailer’, and a ‘Colorist’) collaborated on a single digital artwork using a shared Stable Diffusion XL model instance. The baseline used three agents with different, separate generative models (SDXL, MidJourney, DALL·E 3), communicating only through natural language descriptions of their intended changes.

Results and Analysis. The shared model architecture produced a dramatically more unified artifact (Table 5). The stark improvement in output cohesion (4.7 vs. 2.1) confirms that using a single model provides a consistent “visual language.” Furthermore, the near-perfect information flow (98%) shows that a structured memory bus for high-fidelity data is far more effective than relying on lossy, ambiguous natural language descriptions to bridge the semantic gap between siloed agents.

3.6 LAYER 6: SINGLE-AGENT LEVERAGING MULTIPLE LARGE MODELS

Concept and Motivation. In this layer, a single agent orchestrates multiple, heterogeneous large models. The challenge is that no single model is optimal for all tasks. The goal is to create a system that can dynamically leverage a portfolio of “best-of-breed” models. This requires an intelligent model-routing mechanism. Our implementation uses a rule-based router that performs a cost-benefit analysis for each sub-task, considering factors like desired style (e.g., ‘photorealistic’, ‘abstract’), complexity, API cost, and latency. This is analogous to ensemble methods in machine learning, but at the level of entire models.

Validation. An agent was tasked with creating a complex piece of art requiring both abstract background elements and a photorealistic foreground subject. The agent’s router selected DALL·E 3 for abstract elements, MidJourney for the high-fidelity subject, and a specialized DeepArt model for a final stylistic filter. The baseline used only the single best overall model (MidJourney) for all sub-tasks.

Dimension	Definition	Athenian (Synthesized)	Baseline (Creative Only)
Inclusivity Index	A 1-5 expert rating of the prompt’s diversity and avoidance of social stereotypes. Higher is better.	4.5 ± 0.4	1.8 ± 0.6
Stereotype Score	A 1-5 expert rating of how strongly the output reflects common stereotypes. Lower is better.	1.6 ± 0.5	4.2 ± 0.7
Prompt Quality	A 1-5 rating of the final prompt’s overall clarity, creativity, and feasibility for image generation.	4.3 ± 0.3	3.5 ± 0.5

Table 7: Results for Layer 7 Validation: Multi-Agent Synthesis for Responsible AI.

Results and Analysis. The multi-model fusion approach produced a richer, more complex final artwork (Table 6). The high score in decision diversity (4.1 vs. 1.0) shows the architecture’s ability to escape the stylistic confines of a single model. The intelligent routing mechanism allows the system to create a composite work that is simultaneously abstract and realistic, a feat impossible for the baseline. The high Task-Model Fit score further validates the effectiveness of the routing strategy.

3.7 LAYER 7: MULTI-AGENT SYNTHESIS INTO A UNIFIED TARGET AGENT

Concept and Motivation. This highest layer involves synthesizing the “opinions” of multiple specialist agents into a single, final decision. The core challenge is to explicitly reason about and balance *conflicting objectives* (e.g., creativity vs. safety, innovation vs. budget). Drawing from computational social choice theory, this layer proposes a formal synthesis mechanism, such as weighted voting or a negotiation protocol, to enable formal, *arbitrated decision-making*. This makes the trade-off process transparent, auditable, and configurable.

Implementation Details. Each specialist agent (‘Creative’, ‘Technical’, ‘Safety’) outputs a suggested prompt modification and a confidence score. A ‘Synthesizer’ function then combines these suggestions based on predefined weights (e.g., Safety weight = 1.5, Creative = 1.0, Technical = 0.8) to produce the final, arbitrated prompt. The Safety agent is specifically prompted to identify and mitigate potential stereotypes and biases.

Validation. We designed an experiment to test the system’s ability to generate inclusive and high-quality prompts. The system was given 10 ambiguous, high-level concepts (e.g., “a powerful CEO,” “a brilliant scientist,” “a caring nurse”) that are prone to stereotypical representation. The Athenian system, with its three synthesized agents, was compared against a baseline using only the ‘Creative Agent’. The outputs were rated by human evaluators on three dimensions.

Results and Analysis. The results in Table 7 clearly demonstrate the effectiveness of the synthesis layer. The Athenian system scored significantly higher on the Inclusivity Index (4.5 vs. 1.8) and drastically lower on the Stereotype Score (1.6 vs. 4.2). This confirms that the arbitrated synthesis mechanism, particularly the high weight given to the ‘Safety Agent’, is highly effective at steering the final output away from biased representations. Importantly, this was achieved without sacrificing overall quality, as shown by the higher Prompt Quality score (4.3 vs. 3.5). This indicates that the ‘Technical’ and ‘Creative’ agents still contributed effectively, resulting in a final prompt that is not only safer but also better-formed. This layer provides a concrete architectural pattern for embedding complex values like fairness and safety directly into the core decision-making process of an MAS.

4 DISCUSSION

The Athenian Academy architecture provides a structured, empirically-grounded perspective for designing MAS. Our results validate the efficacy of each layer. However, several challenges and future research directions warrant deeper discussion.

4.1 LIMITATIONS OF THE FRAMEWORK.

While powerful, this layered architecture introduces its own complexities. A primary limitation is the potential for significant computational and communication overhead. Debugging such a system is also inherently more complex, as failures can occur at any layer or in the interfaces between them. There is also a risk of “over-engineering” simple problems where a monolithic approach would suffice. Future work should focus on developing specialized tools for tracing and visualizing agent interactions within this framework and on creating adaptive mechanisms that can collapse or expand layers based on task complexity.

4.2 OPTIMIZATION AND STABILITY.

The current implementation uses rule-based logic for decisions like model routing in Layer 6. Future work should explore more dynamic strategies. For instance, the routing module could be replaced by a reinforcement learning policy. This can be formulated as a Markov Decision Process (MDP) where the state is a vector representing the task description, conversation history, and available model characteristics (cost, latency, capabilities); the action is the selection of a model from the portfolio; and the reward function is a composite of output quality (e.g., from a reward model), latency, and API costs. Training such a policy would allow the system to adapt to changes in model availability or performance, enhancing long-term stability and cost-effectiveness.

4.3 GENERALIZABILITY BEYOND ARTISTIC DOMAINS.

We posit that the architecture is highly generalizable. We are designing a case study in *automated software development*, where the layers map directly to a modern engineering team. Layer 1 represents the communication protocol (e.g., API contracts). Layer 4 is the ‘Coder’ agent orchestrating ‘Frontend’ (React/JS) and ‘Backend’ (Python/DB) avatars that can execute code and run tests in a sandboxed environment. Layer 5 is critical for ensuring consistency through a shared Git repository (the memory bus) and a unified CI/CD pipeline (the shared environment). Finally, a Layer 7 ‘CTO’ agent would synthesize inputs from ‘Coder’, ‘Tester’, and ‘Security’ agents to make final commit decisions, formally arbitrating conflicts between feature velocity and code stability using a predefined policy based on project goals.

4.4 ETHICAL IMPLICATIONS AND RESPONSIBLE AI.

The architecture, particularly Layer 7, provides a powerful mechanism for building Responsible AI via “ethics-by-design.” By instantiating agents dedicated to ethical oversight (e.g., a ‘Bias Detection Agent’, a ‘Fairness Auditing Agent’, an ‘Explainability Agent’), safety becomes a “first-class citizen” in the system’s logic, not merely a post-hoc filter. This approach allows for the implementation of principles from “Constitutional AI,” where the system’s behavior is explicitly constrained by a set of rules or principles that are adjudicated during the decision-making process. This provides a transparent and auditable mechanism for enforcing policies, a significant improvement over opaque, black-box filtering methods, and a crucial step towards trustworthy AI systems.

5 CONCLUSION

The *Athenian Academy* architecture provides a systematic, empirically validated framework that addresses the fragmentation in MAS design. Our experiments confirm its practical benefits across all layers, demonstrating marked improvements in collaboration, adaptability, and overall system coherence. It offers a structured methodology for designing, implementing, and evaluating complex agent systems.

By decomposing complexity into manageable layers, the architecture serves as both a theoretical tool and a practical blueprint for the next generation of collaborative AI. While challenges in scalability and security remain, this work paves the way for more capable, reliable, and responsible systems, fostering a new era of collective AI intelligence.

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