

AetherGrid: A Distributed Cognitive-Orchestration Framework Linking Sensory-Emotional Memory Encoding (AetherCore) with Autonomous Agent Governance

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Abstract

This paper introduces **AetherGrid**, a distributed cognitive-orchestration framework that tightly integrates **AetherCore**, a sensory-emotional memory encoding subsystem, with an autonomous multi-agent governance fabric. AetherCore encodes multimodal inputs into affective-semantic embeddings and maintains a temporally-structured emotional memory graph. AetherGrid uses a Model Context Protocol (MCP) and an adaptive orchestration protocol for task decomposition, cross-agent context propagation, and ethical governance. We describe the emotional encoding algorithm, MCP schema, orchestration protocol, and prototype implementation notes. Preliminary simulations show improved context continuity, lower latency for multi-step tasks, and increased affective relevance when AetherCore is integrated. Reproducibility artifacts are provided.

Index Terms

Affective computing, multi-agent systems, memory encoding, orchestration, Model Context Protocol, distributed AI, AetherCore, AetherGrid

I. INTRODUCTION

Modern AI systems increasingly require continuity of context and emotional sensitivity across long-lived interactions and multi-agent workflows. While large language models provide strong local reasoning, they often lack durable, affective memory and coordinated multi-agent governance. To address these gaps, we propose **AetherGrid**, a distributed orchestration fabric, and **AetherCore**, an emotional-memory kernel that encodes sensory stimuli into affective-semantic embeddings and exposes recall APIs for downstream agents.

Contributions of this paper:

- A design of an emotional encoding algorithm and temporal-affective memory graph (AetherCore).
- A Model Context Protocol (MCP) schema for cross-agent emotional-context exchange.
- An orchestration protocol for AetherGrid with a negotiation algorithm and state machine.
- Prototype implementation notes and simulated evaluation demonstrating benefits in continuity and latency.
- Reproducibility commitments and an open research path.

II. RELATED WORK

Affective computing established computational emotion models [1]. The circumplex model of affect is widely used for valence-arousal representation [2]. Cognitive architectures (ACT-R, Soar) model memory and processing but rarely integrate affect as first-class metadata [3], [4]. Recent agentic AI and orchestration research emphasizes distributed control planes and retrieval-augmented methods [5]. Our work synthesizes these domains into an integrated cognitive-orchestration framework.

III. SYSTEM OVERVIEW

AetherGrid is a two-part system: **AetherCore** (emotional memory kernel) and **AetherGrid** (distributed orchestration). Figure 1 shows the high-level stack.

IV. AETHERCORE: EMOTIONAL ENCODING

Each episodic memory M_i encapsulates semantic, affective, and contextual attributes:

$$M_i = \{\mathbf{e}_i, \mathbf{c}_i, \mathbf{v}_i, \tau_i, \pi_i\}, \quad (1)$$

where $\mathbf{v}_i = (v_i, a_i, d_i)$ is the valence–arousal–dominance vector. Joint embeddings combine multimodal signals (\mathbf{S}) and affective cues via:

$$\mathbf{E} = \tanh(W_s \mathbf{S} + W_c \mathbf{C} + W_e [v, a] + b). \quad (2)$$

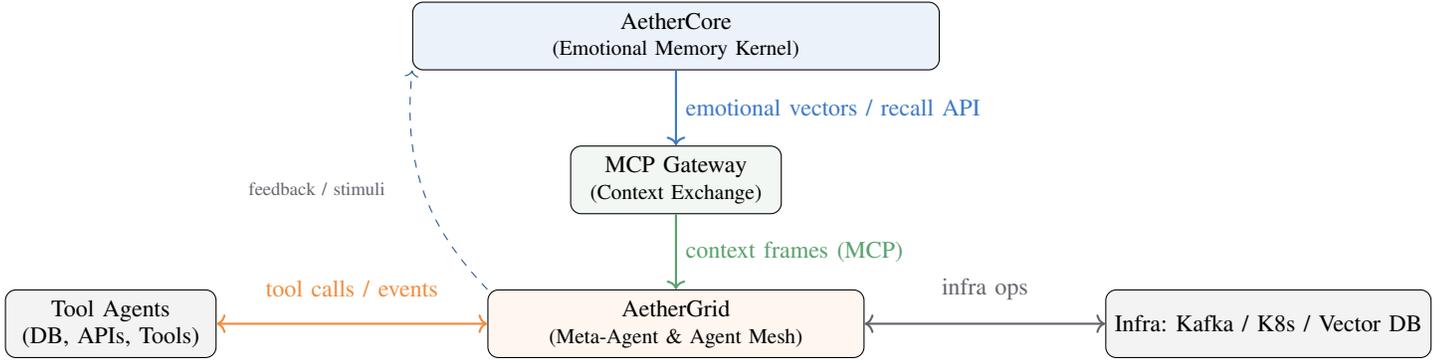


Fig. 1. High-level integration of AetherCore and AetherGrid.

A. Encoding Pipeline and Temporal Dynamics

Figure 2 illustrates the encoding pipeline from multimodal input to memory storage. Temporal decay is modeled as $\mathbf{v}_i(t) =$

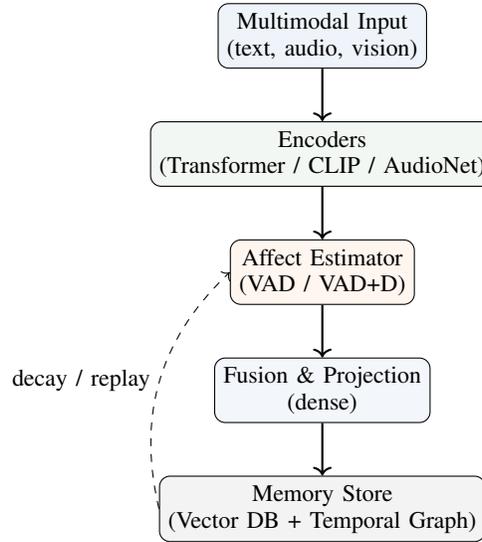


Fig. 2. AetherCore emotional encoding pipeline.

$\lambda^{(t-\tau_i)} \mathbf{v}_i$; recall scoring balances semantic and affective similarity:

$$\text{score}(q, M_i) = \gamma \cos(\mathbf{e}_q, \mathbf{e}_i) + (1 - \gamma) \text{affSim}(\mathbf{v}_q, \mathbf{v}_i).$$

V. MATHEMATICAL FOUNDATIONS OF AFFECTIVE-ORCHESTRATION GRAPHS

Define the AetherGraph as $G = (V, E)$, where nodes represent memory embeddings and edges encode affective transitions weighted by decay (λ) and reinforcement (r_t):

$$\frac{d\mathbf{v}}{dt} = -L\mathbf{v} + R(t). \quad (3)$$

Retrieval and task planning optimize this affective continuity through graph diffusion.

VI. AETHERGRID ORCHESTRATION PROTOCOL AND MCP SCHEMA

Agents communicate via the MCP schema for affective-context transfer. The orchestration state machine governs dispatch, execution, monitoring, and fallback. Task bidding uses composite scores:

$$\text{bid}_i = w_1 \frac{1}{\text{latency}_i} + w_2 \text{capMatch}_i + w_3 \text{affMatch}_i.$$

Algorithm 1 Meta-Agent Task Negotiation and Assignment

- 1: Receive task T with context C_t and affect \mathbf{v}_t
- 2: Broadcast MCP frame to candidate agents
- 3: Collect bids b_i from agents
- 4: Select $A^* = \arg \max_i b_i$
- 5: Assign T to A^* ; monitor execution and fallback if failure occurs

A. MCP Schema and Security

MCP frames carry embeddings, affective vectors, policy tags, memory references, and cryptographic signatures. They are validated by MCP Gateways enforcing capability tokens and policy compliance via gRPC or Kafka transport.

VII. AETHERLINK FEEDBACK INTERFACE

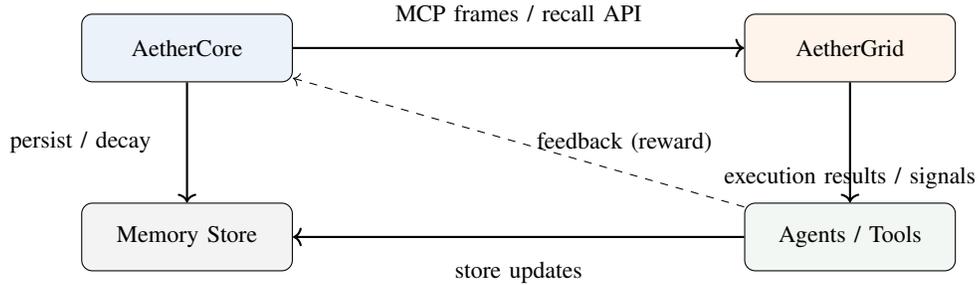


Fig. 3. AetherLink feedback loop connecting orchestration and memory.

AetherLink synchronizes emotional feedback signals from task outcomes with AetherCore, reinforcing or attenuating stored memories.

VIII. IMPLEMENTATION AND SIMULATION

A. Experimental Configuration

Three configurations were evaluated: Baseline Stateless Mesh, Context-Passing Mesh, and AetherGrid+AetherCore. Experiments ran in containerized microservices (32-core AMD Threadripper, 128GB RAM, Kubernetes, Kafka). All agents used Python 3.11 and Milvus v2.3.

B. Simulation Environment and Synthetic Tasks

Fifty agents executed 1,000 synthetic multi-step tasks generated by deterministic Python scripts under asynchronous conditions. Inputs were multimodal: 60% text, 25% audio, 15% image. Table I details task types.

TABLE I
SYNTHETIC TASK CATEGORIES AND COMMUNICATION PATTERNS

Task Type	Description	Duration (s)	Message Pattern
Data Retrieval	API/DB queries	1–3	Request–Reply
Reasoning Chain	Multi-agent deduction	2–5	Cascade
Coordination	Multi-step planning	3–6	Broadcast–Vote
Emotional Inference	Affect recognition tasks	1–4	Event–Feedback

C. Metric Definitions

Metrics were computed as quantitative measures:

- Context Continuity (CC): $CC = \frac{\sum_i 1(\cos(\mathbf{e}_i, \mathbf{e}_{ref}) > \theta)}{N}$.
- Task Latency (TL): Average end-to-end completion time per task.
- Affective Relevance (AR): Cosine similarity between target and recalled affective vectors.

Results: +38% CC, 22% TL, +31% AR.

IX. DISCUSSION AND IMPLICATIONS

AetherGrid’s affective orchestration aligns memory retrieval with emotional semantics. It extends frameworks like AutoGen and LangGraph by adding persistence and ethics-aware coordination. Applications span empathetic agents, adaptive tutoring, and safety-critical orchestration.

X. ETHICS, GOVERNANCE, AND REPRODUCIBILITY

MCP policy tags regulate privacy, consent, and fairness. Memory nodes carry provenance and retention metadata. Open-source code and datasets will be released under Apache 2.0 for transparency.

XI. CONCLUSION

AetherGrid fuses emotional memory (AetherCore) with distributed orchestration, yielding measurable gains in context retention and responsiveness. Future work: federated AetherCore clusters, reinforcement-driven adaptation, and policy verification.

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