STRUCTURED KNOWLEDGE ACCUMULATION (SKA) AI INFRASTRUCTURE TOPOLOGY

A Human–Agent System for Spontaneous Emergent Collective Intelligence

These diagrams abstract the SKA AI Infrastructure beyond hardware and software, illustrating the universal structure of knowledge flow between humans and intelligent agents — the foundation of spontaneous emergent collective intelligence.

Definition of a Pod in the SKA Infrastructure

A **pod** in the Structured Knowledge Accumulation (SKA) AI Infrastructure is an **aggregation of interconnected nodes**—both human and AI—that continuously exchange timestamped knowledge events through a time-series database. Each pod functions as a *knowledge layer*, where all communications between nodes are recorded as entries $M_{ij}(t)$ in the Message Bus Memory Matrix. Through this continuous accumulation of structured knowledge, pods form the **foundation of spontaneous emergent collective intelligence** across the distributed SKA network.

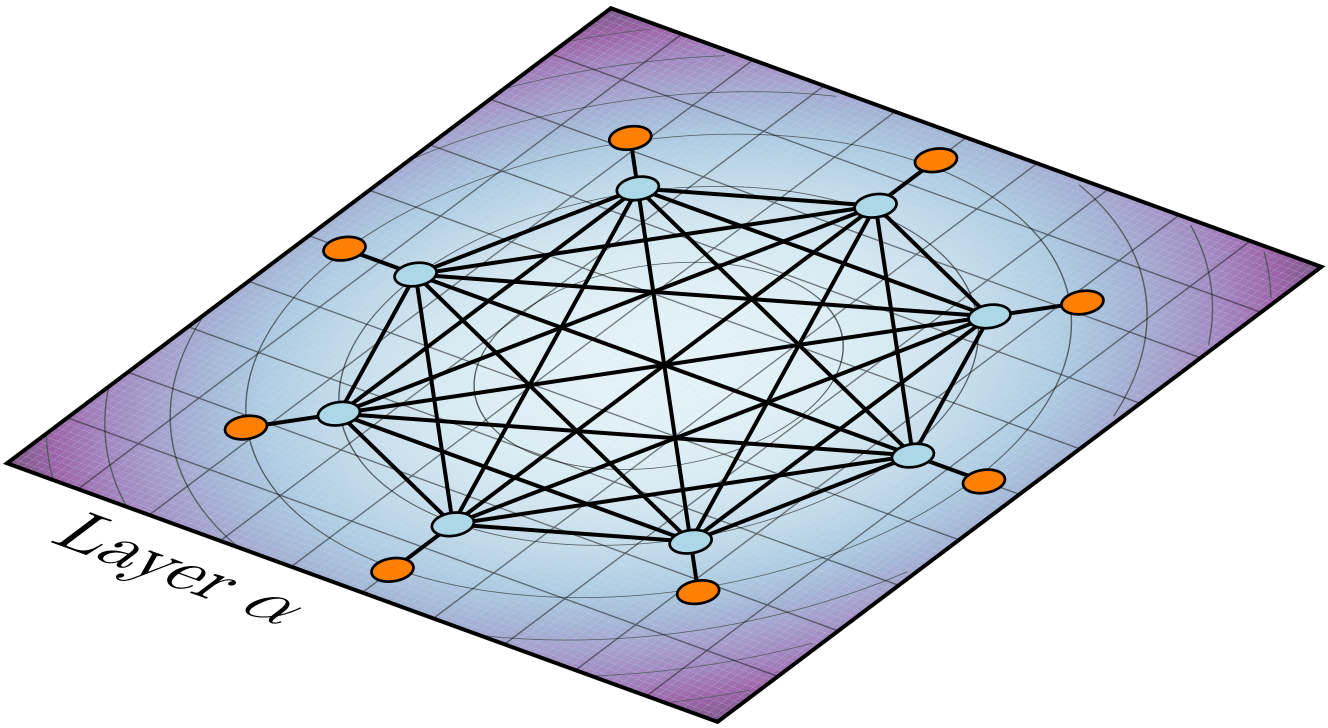

Figure 1: Simplified SKA AI Infrastructure – Human–Agent Network. Outer circle: human participants (H_i, orange). Inner circle: AI agents (A_i, blue). Arrows depict communication and the shared knowledge layer between agents.

Message Bus Memory Matrix

A structured representation of message exchanges between agents (human and AI), captured from the in-memory message bus and persisted for database querying.

$$\begin{bmatrix} M_{11} & M_{12} & M_{13} & M_{14} & M_{15} & M_{16} & M_{17} & M_{18} \\ M_{21} & M_{22} & M_{23} & M_{24} & M_{25} & M_{26} & M_{27} & M_{28} \\ M_{31} & M_{32} & M_{33} & M_{34} & M_{35} & M_{36} & M_{37} & M_{38} \\ M_{41} & M_{42} & M_{43} & M_{44} & M_{45} & M_{46} & M_{47} & M_{48} \\ M_{51} & M_{52} & M_{53} & M_{54} & M_{55} & M_{56} & M_{57} & M_{58} \\ M_{61} & M_{62} & M_{63} & M_{64} & M_{65} & M_{66} & M_{67} & M_{68} \\ M_{71} & M_{72} & M_{73} & M_{74} & M_{75} & M_{76} & M_{77} & M_{78} \\ M_{81} & M_{82} & M_{83} & M_{84} & M_{85} & M_{86} & M_{87} & M_{88} \end{bmatrix}$$

Figure 2: **Message Bus Memory Matrix — Quantitative Memory Representation.** Each element M_{ij} denotes the *amount of memory* allocated, shared, or retained from node i to node j (human or AI). This matrix forms the quantitative backbone of the SKA Infrastructure, encoding how much structured knowledge persists across the distributed network.

The Matrix Structure of the Knowledge Layer

The Message Bus Memory Matrix M reveals a fundamental structural principle underlying intelligence across diverse implementations. Any system that integrates information from multiple sources to produce decisions must possess a connectivity matrix encoding both the topology of information flow and the strength of inter-component coupling. In the SKA framework, M_{ij} quantifies accumulated knowledge from node i to node j, serving simultaneously as both architecture and content. The diagonal elements M_{ii} capture human-agent interaction depth, establishing epistemic grounding, while off-diagonal elements M_{ij} $(i \neq j)$ encode agent-to-agent knowledge synthesis, enabling emergent coordination. This matrix structure enables systematic analysis of knowledge flow in distributed intelligence systems: rows index information sources, columns index destinations, and values encode coupling strength. The SKA contribution lies in making this matrix explicit, observable, and governed by forward-only accumulation dynamics rather than retroactive update mechanisms, thereby achieving greater biological plausibility while preserving causality and enabling complete auditability of knowledge flow throughout the system's temporal evolution.

1 Multilayer Knowledge Topology

1.1 Simplified Multilayer Knowledge Topology

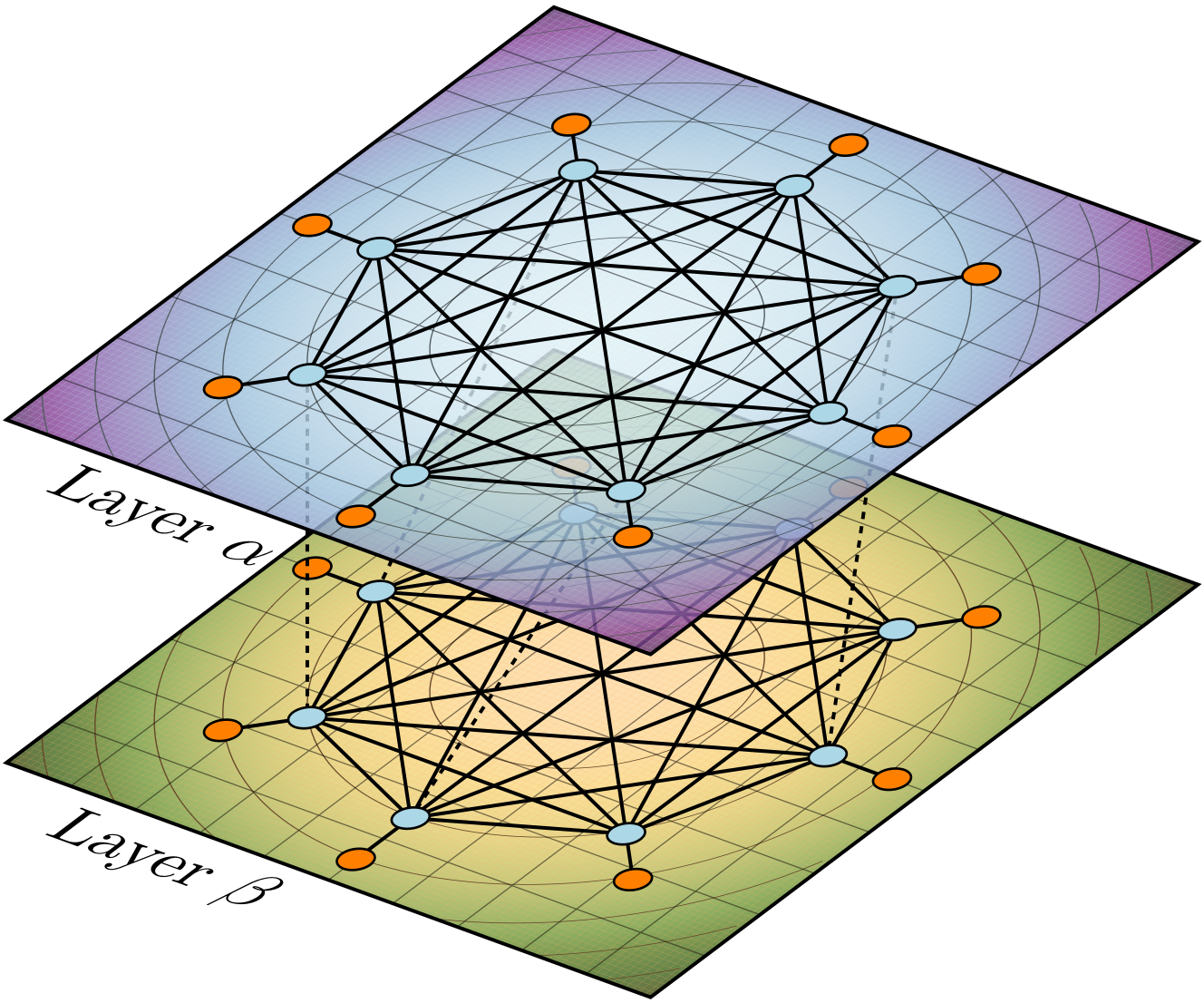

Figure 3: **Simplified Multilayer Knowledge Topology.** Each plane represents a layer of structured knowledge accumulation within the SKA framework. Layer α (blue) and Layer β (green) illustrate interacting networks of human and AI nodes. Edges denote knowledge exchange events governed by forward-only entropy reduction. Dashed inter-layer links represent the coupling between layers through the Message Bus Memory Matrix $M_{ij}(t)$, showing how accumulated knowledge propagates across hierarchical levels of the SKA infrastructure.

Each element $M_{ij}(t)$ in the Message Bus Memory Matrix corresponds to a timestamped knowledge event persisted in the time-series database. To ensure auditability across distributed experiments, each M_{ij} entry is differentiated by a dedicated `pod_id` column, uniquely identifying the source pod within the SKA infrastructure. This allows complete reconstruction of knowledge flow between agents and pods, making the knowledge topology both interpretable and empirically verifiable in real time.

1.2 Early-Stage Multilayer Knowledge Topology

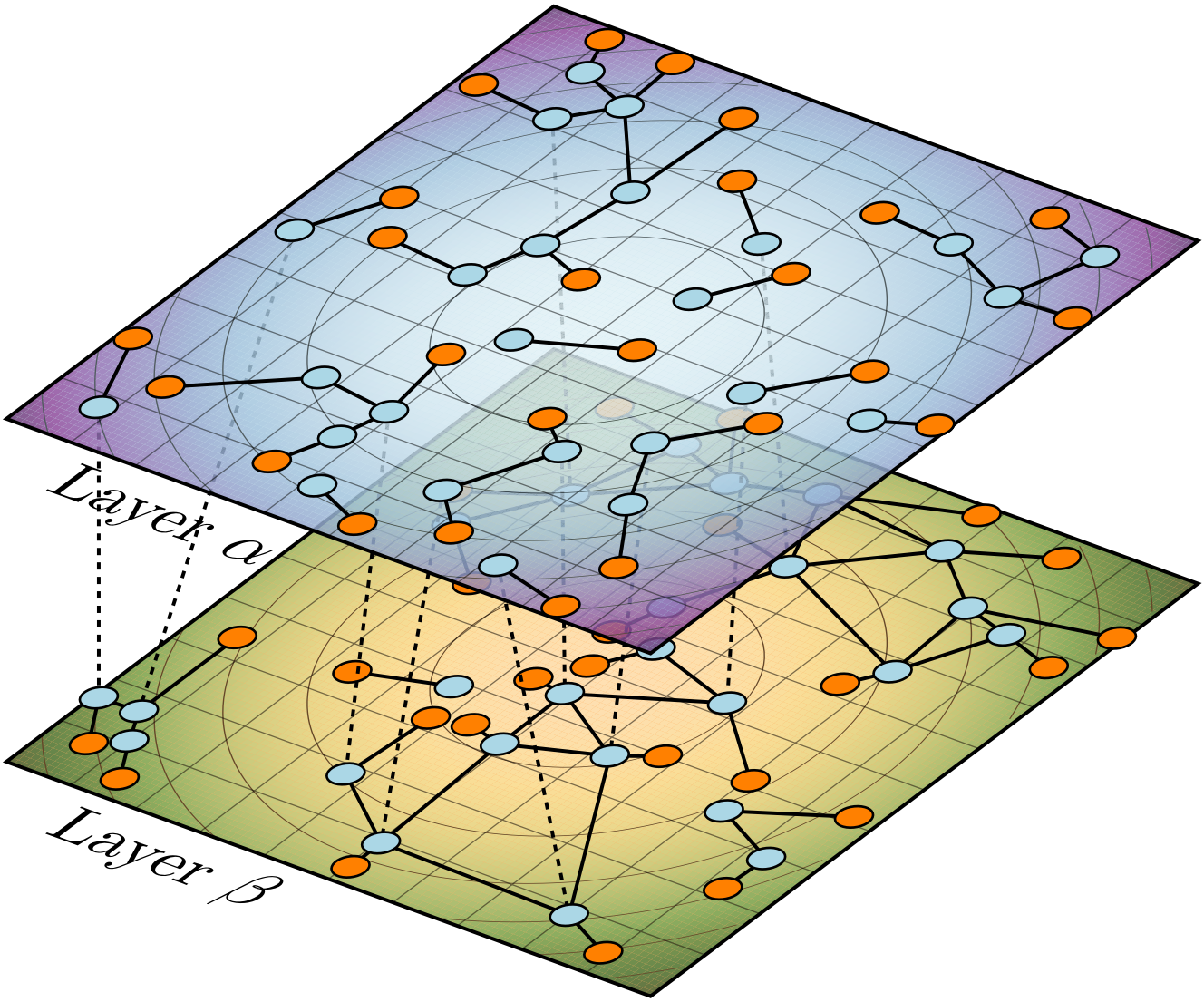

Figure 4: **Early stage of the emergence of collective intelligence.** Each orange node represents a human, and each blue node an AI agent. Every human is connected to a single paired AI agent, forming localized human–AI units. At this stage, the overall network is only partially connected: some links exist between agents, but global coordination has not yet emerged. Forward-only learning will gradually strengthen the interconnections between these grounded pairs, allowing shared knowledge to propagate through the network until collective intelligence forms

2 Research Context and Validation Framework

This topology represents a validation platform for the Structured Knowledge Accumulation (SKA) theoretical framework, which proposes that intelligent behavior can emerge from forward-only knowledge accumulation without traditional backpropagation. The infrastructure enables controlled experiments to test whether bidirectional communication between nodes (where $M_{ij} \neq 0$ AND $M_{ji} \neq 0$) produces measurable entropy reduction and emergent collective intelligence. By capturing all agent interactions as timestamped, immutable knowledge events, the system provides an empirical testbed for investigating alternative learning paradigms.