

SUPPLEMENTARY APPENDIX: ADC Schema Examples for the DigiMind Cognitive ADC Architecture

Abstract—This appendix provides detailed schema examples illustrating the architecture’s core feature of Vertical Flexibility and Granular Evolution, demonstrating how the system adapts its structural depth and bit-resolution based on domain complexity quantified by Knowledge Entropy (\mathcal{H}_K).

I. ADC SCHEMA EXAMPLES: FIXED, FLEXIBLE, AND GRANULAR

These tables illustrate the structure of the DigiMind architecture: the foundation schema, two examples of vertical flexibility, and the granular evolution mechanisms.

A. Example A1: Foundational 4-Layer Fixed Bit-Depth (2^{40} Uneven Base)

This shows the initial, yet non-uniform, base architecture ($D = 4$), prioritizing the upper layers for domain differentiation, Table:(I).

TABLE I: **Foundational Schema: Fixed 40-Bit Allocation** ($16 + 12 + 8 + 4$)

Layer	Function	Bit-Depth ($B_{j,l}$)	Node Count ($2^{B_{j,l}}$)	Resource Usage
L_1	Major Domain	16	65,536	Large LLM
L_2	Sub-Domain	12	4,096	Medium LLM
L_3	Conceptual Node	8	256	Light LLM
L_4	Feature/Fact Node	4	16	Feature Weight

Total Bits: $16 + 12 + 8 + 4 = 40$ bits. Total Layers: 4.

B. Example A2: Vertical Flexibility (Shallow Depth - 3 Layers)

This example demonstrates a shallow schema architecture where the total knowledge complexity (\mathcal{H}_K) is concentrated at the upper layers, resulting in a path depth of $D = 3$. This is efficient for highly structured, less granular data, Table:(II).

C. Example A3: Vertical Flexibility (Deep Depth - 7 Layers)

This example demonstrates a deep architecture required for domains with high, complex, and evolving knowledge entropy, such as Theoretical Physics. The path depth is expanded to $D = 7$ layers, showcasing the maximum structural plasticity, Table:(III).

This supplementary material accompanies the manuscript "DigiMind: A Cognitive ADC Architecture for Continual Learning and Factual Coherence."

TABLE II: **Vertical Flexibility Schema: Shallow Geo-Location Example** ($M_{\text{Geography}}$)

Layer	Function	Bit-Depth ($B_{j,l}$)	Node Count ($2^{B_{j,l}}$)	Resource Usage
L_1	Major Schema: Country	16	65,536	Large LLM
L_2	Sub-Schema: City/Region	8	256	Medium LLM
L_3	Feature: Capital of City	4	16	Feature Weight

Total Bits: $16 + 8 + 4 = 28$ bits. Total Layers: 3. (Optimized for low-depth factual structure.)

TABLE III: **Vertical Flexibility Schema: Deep Physics Example** (M_{Physics})

Layer	Function	Bit-Depth ($B_{j,l}$)	Node Count ($2^{B_{j,l}}$)	Resource Usage
L_1	Major Field (e.g., Quantum)	16	65,536	Large LLM
L_2	Core Theory (e.g., QFT)	12	4,096	Medium LLM
L_3	Model Class (e.g., Standard Model)	8	256	Medium LLM
L_4	Sub-Model/Symmetry Group	4	16	Light LLM
L_5	Specific Parameter/Equation Set	8	256	Light LLM
L_6	Experimental Context/Setup	8	256	Feature Weight
L_7	Specific Datum/Reference Fact	8	256	Feature Weight

Total Bits: $16 + 12 + 8 + 4 + 8 + 8 + 8 = 64$ bits. Total Layers: 7. (Optimized for deep, multi-layered concepts.)

D. Example A4: Granular Evolution: Localized Horizontal Bit-Depth Upgrade: 4 bits to 8 bits

This demonstrates the **horizontal bit-depth upgrade**. A terminal module (M_{L4}) is upgraded from 4 bits (16 slots) to 8 bits (256 slots) due to a surge in fine-grained information within its domain, Table:(IV).

TABLE IV: **Simulated Granular Evolution: Horizontal Bit-Depth Upgrade**

Component /Phase	Pre-Upgrade State	Upgrade Trigger & Action	Post-Upgrade State & Result
Target Module M_{L4}	Adaptive Algos (Feature LLM). Bit-Depth: 4 bits. Capacity: 16 feature slots.	High \mathcal{H}_K detected; module capacity exceeds 80%.	Bit-Depth is increased to 8 bits. Capacity: 256 feature slots.
Upgrade Method	N/A	Localized PEFT applied only to the M_{L4} weight matrix and its routing layer weights.	Cost Efficacy: Only the smallest relevant part of the network is trained.
Peer Module M_{L4}'	Second-Order Methods (Feature LLM). Bit-Depth: 4 bits.	No Action. Module is stable (low \mathcal{H}_K).	Zero Interference: M_{L4}' is entirely protected and unaffected by the upgrade.

E. Example A5: Granular Evolution: Vertical Layer Expansion (Split Operation)

This demonstrates the **vertical layer expansion**, where a high-entropy terminal node (M_{L4}) is replaced by a new routing layer and two new sub-modules, increasing the path depth from 4 layers to 5, Table:(V).

TABLE V: **Simulated Granular Evolution: Vertical Layer Expansion (Split Operation)**

Component /Phase	Pre-Expansion State	Expansion Trigger & Action	Post-Expansion State & Result
Target Path Depth	$D = 4$: Path ends at $L4$.	N/A	$D = 5$: New path segment $L4 \rightarrow L5$.
Target Module M_{L4}	Single, high-entropy module for $M_{Transporters}$.	High \mathcal{H}_K in M_{L4} . Knowledge becomes conceptually separable (<i>Passive</i> vs. <i>Active</i> Transport).	M_{L4} is converted into a Router Node ($L4$ -Router).
New Structure	N/A	$M_{Transporters}$ weights are cloned and initialized with antisymmetric perturbation ($W_{old} \pm \epsilon$).	New Layer 5 created: $M_{L5_Passive}$ and M_{L5_Active} .