[Technical Abstract]

Title: The Neural Forest Paradigm: A Distributed, Inference-First Architecture for Heterogeneous Ryzen AI Systems

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Background: Modern Artificial Intelligence is currently constrained by the "Crisis of the Monolith"—a paradigm of brute-force parameter scaling in Transformer models that has led to a "Memory Wall." This bottleneck, defined by the latency between high-bandwidth memory (HBM) and compute units, creates unsustainable energy demands and thermal throttling, particularly in mobile and edge-computing environments. As the industry transitions from the "Training Era" to the "Inference Era," there is a critical requirement for architectures that prioritize modularity and data-locality over raw FLOPs.

Proposed Solution: This paper introduces the **Neural Forest (NF)**, a subsymbolic, highly parallelized ensemble learning framework. Unlike monolithic deep networks, the NF utilizes a "forest" of thousands of **Neural Trees**—specialized, task-specific computational atoms (MLPs, CNNs, or RNNs). By employing "forced specialization," the NF optimizes the bias-variance trade-off, achieving superior predictive stability and mechanistic interpretability. A meta-cognitive "Conductor" provides dynamic task routing, activating only the relevant branches of the forest for any given input, thereby reducing the computational footprint of inference by orders of magnitude.

Hardware Synergy & Implementation (NF-Core): The NF architecture is designed to exploit the specific strengths of **AMD's Ryzen AI** and the **XDNA** heterogeneous engine. The proposed **NF-Core** accelerator replaces traditional GPGPU-centric designs with:

1. **Heterogeneous Micro-Cores:** Specialized processing elements optimized for diverse data modalities (spatial, temporal, and symbolic).
2. **Distributed On-Chip Memory:** Strategic placement of weights within SRAM/eDRAM adjacent to arithmetic units to dismantle the Von Neumann Bottleneck and eliminate energy-intensive DRAM trips.
3. **Reconfigurable Network-on-Chip (NoC):** An adaptive topology enabling the non-uniform data routing required for dynamic ensemble activation.

Strategic Impact for AMD: Integration of the Neural Forest paradigm into the Ryzen AI

ecosystem offers three primary strategic advantages:

- **Superior Power Efficiency:** Conditional execution ensures that AI-powered PCs (Copilot+ laptops) maintain high performance-per-watt, extending battery life during complex agentic workflows.
- **Scalable Edge Intelligence:** The modular nature of Neural Trees allows for easier deployment of high-fidelity models on NPU-constrained hardware compared to monolithic LLMs.
- **Competitive Differentiation:** By providing a silicon-optimized substrate for modular AI, AMD can bypass the GPGPU software moat of competitors, positioning Ryzen AI as the premier platform for the next generation of sustainable, interpretable Artificial General Intelligence (AGI).

Conclusion: The Neural Forest provides a hardware-integrated blueprint for moving beyond the limitations of monolithic AI. By aligning NF-specific software libraries with future AMD silicon revisions, the Ryzen AI ecosystem can lead the industry's shift toward distributed, resilient, and energy-efficient intelligence.