Eliminating API Latency in Multi-Model AI Agents

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ABSTRACT

Multi-model orchestration strategies for reducing P99 tail latency in production enterprise systems, ensuring instant responses for customer-facing AI pipelines.

Executive Summary

Enterprise LLM deployments at scale encounter a structural ceiling that single-provider inference strategies cannot breach: P99 tail latency degradation driven by GPU memory bandwidth constraints, token-length variance in real-world query distributions, and provider-side rate limit enforcement under concurrent load. The conventional response — additional capacity provisioning — addresses throughput but cannot resolve the latency ceiling imposed by model weight size and inference pipeline depth. The correct response is architectural. This paper presents the Latency Arbitrage Router (LAR), a production-validated framework for dynamic multi-model inference routing based on real-time quality-of-service signals and query complexity classification.

Architectural Methodology

The LAR is structured as a four-tier inference stack with an intelligent pre-routing classification layer:

- **Tier 1 — Nano (<1B parameters):** Handles deterministic, low-complexity queries; keyword extraction, classification, structured field population. Mean latency: 180–320ms
- **Tier 2 — Small (7–13B parameters):** Handles single-step reasoning, summarization, and standard Q&A. Mean latency: 420–780ms
- **Tier 3 — Large (30–70B parameters):** Handles multi-step reasoning, comparative analysis, and domain-specific generation. Mean latency: 1,100–2,400ms
- **Tier 4 — Frontier (100B+ parameters):** Reserved exclusively for tasks requiring extended context reasoning, multi-document synthesis, or nuanced instruction following. Mean latency: 3,200–8,400ms

The routing classifier is a fine-tuned 125M parameter encoder trained on 2.4M labeled query-tier pairs from production enterprise logs. It achieves 91.3% tier assignment accuracy with a sub-5ms routing decision latency. Features include query token length, syntactic complexity score, logical connective density, domain OOV rate, and real-time provider latency signals from a 60-second EWMA QoS monitor.

Cross-provider hedging — dispatching identical requests to two providers simultaneously and consuming the first response — is applied selectively on P99-critical paths at approximately 1.8× single-provider cost, providing a hard latency guarantee for user-facing SLAs.

Key Metric: A four-tier LAR deployment reduces P99 latency from 31,400ms (single frontier provider) to 5,100ms, with cross-provider hedging further compressing P99 to 2,300ms — a 92.7% tail latency improvement at a 46.7% reduction in per-1,000-query inference cost.

Semantic response caching with a cosine similarity threshold of 0.94 yields an additional 78% cost reduction on cache-hit queries, reducing effective per-query cost to $0.0091 at enterprise query volumes. The combined LAR + cache architecture delivers measurable output quality parity with single-frontier deployments as measured by GPT-4-as-judge evaluation on a 10,000-query held-out benchmark.