

Semantic-aware LLM- Application Scheduling

Otto White

December 10, 2025

Introduction

Introduction

- AI performance is improving across all downstream tasks

Introduction

- AI performance is improving across all downstream tasks
- \$390 billion now -> \$4.33 trillion in 2033 (projected by UN Trade and Development)

Introduction

- AI performance is improving across all downstream tasks
- \$390 billion now -> \$4.33 trillion in 2033 (projected by UN Trade and Development)
- It's expensive!

Utilising LLM Applications

Easier than ever to write

Hard to productionize

Utilising LLM Applications

Easier than ever to write

Hard to productionize

- LangChain, LlamaIndex, Pydantic AI, ...

Utilising LLM Applications

Easier than ever to write

Hard to productionize

- LangChain, LlamaIndex, Pydantic AI, ...
- LLM Engines - vLLM, SGLang

Utilising LLM Applications

Easier than ever to write

Hard to productionize

- LangChain, LlamaIndex, Pydantic AI, ...
- LLM Engines - vLLM, SGLang
- Public APIs

Utilising LLM Applications

Easier than ever to write

- LangChain, LlamaIndex, Pydantic AI, ...
- LLM Engines - vLLM, SGLang
- Public APIs

Hard to productionize

- Reliability, Guardrails, Security

Utilising LLM Applications

Easier than ever to write

- LangChain, LlamaIndex, Pydantic AI, ...
- LLM Engines - vLLM, SGLang
- Public APIs

Hard to productionize

- Reliability, Guardrails, Security
- **Performance & Efficiency** (our focus)

Utilising LLM Applications

Easier than ever to write

- LangChain, LlamaIndex, Pydantic AI, ...
- LLM Engines - vLLM, SGLang
- Public APIs

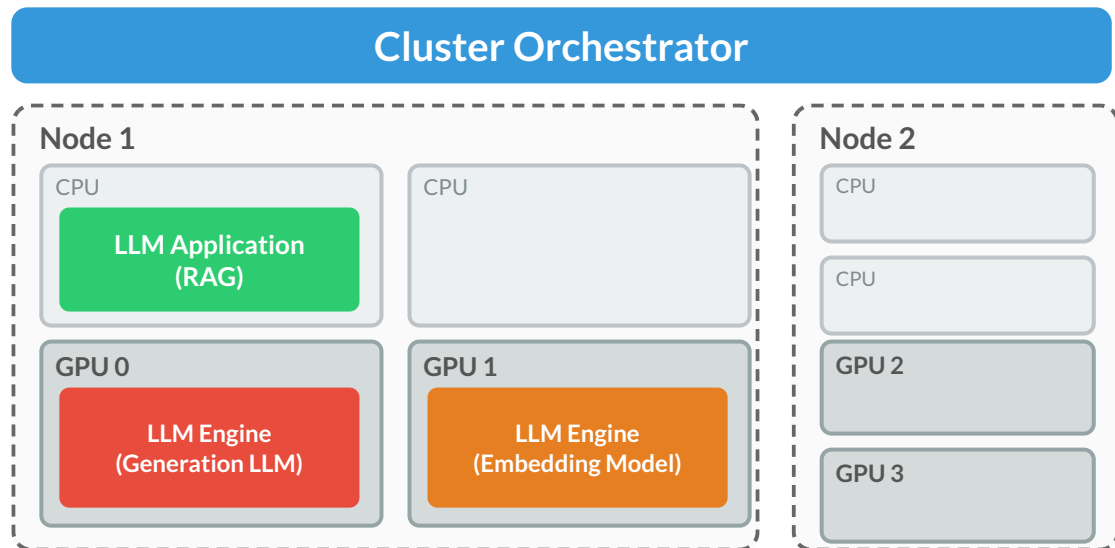
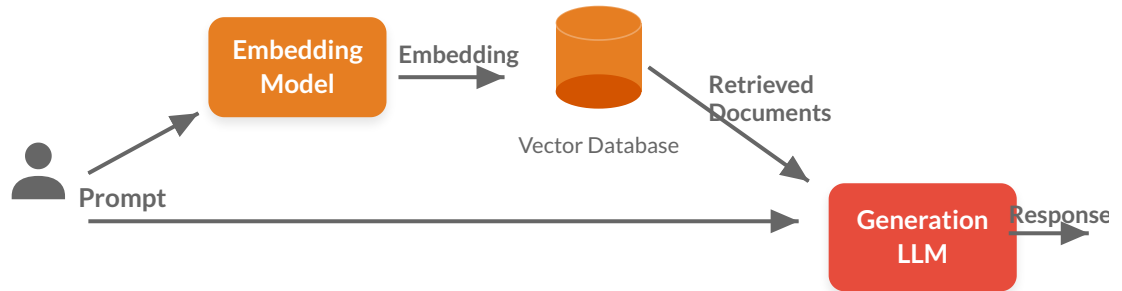
Hard to productionize

- Reliability, Guardrails, Security
- **Performance & Efficiency** (our focus)

Infeasible for companies at smaller scale to achieve efficient deployments applications. They need automated solutions.

LLMs → LLM Applications




- LLM Invocations -> Graphs
- Can't optimise for end-to-end performance
- Lack of Critical Path Awareness
- Unfairness



Related Work

System	Level	Multi-Engine	Application-Aware	Scheduling Granularity /Co-location

Related Work

System	Level	Multi-Engine	Application-Aware	Scheduling Granularity /Co-location
Autellix	LLM Engine			

Related Work

System	Level	Multi-Engine	Application-Aware	Scheduling Granularity /Co-location
Autellix	LLM Engine	✗	✓	✗
MuxServe	Orchestration	✓	✗	✓

Related Work

System	Level	Multi-Engine	Application-Aware	Scheduling Granularity /Co-location
Autellix	LLM Engine	✗	✓	✗
MuxServe	Orchestration	✓	✗	✓
Kubernetes	Orchestration	✓	✗	✗

Related Work

System	Level	Multi-Engine	Application-Aware	Scheduling Granularity /Co-location
Autellix	LLM Engine	✗	✓	✗
MuxServe	Orchestration	✓	✗	✓
Kubernetes	Orchestration	✓	✗	✗
KServe	Orchestration	✓	✗	✗

Critical-path *Aware* Parallelism

Critical-path *Aware* Parallelism

- K8S default behavior:

Critical-path *Aware* Parallelism

- K8S default behavior:
 - One model per GPU

Critical-path Aware Parallelism

- K8S default behavior:
 - One model per GPU
 - Reactively scales based on queue sizes

Critical-path Aware Parallelism

- K8S default behavior:
 - One model per GPU
 - Reactively scales based on queue sizes
 - Optimizes throughput, no latency awareness

Critical-path Aware Parallelism

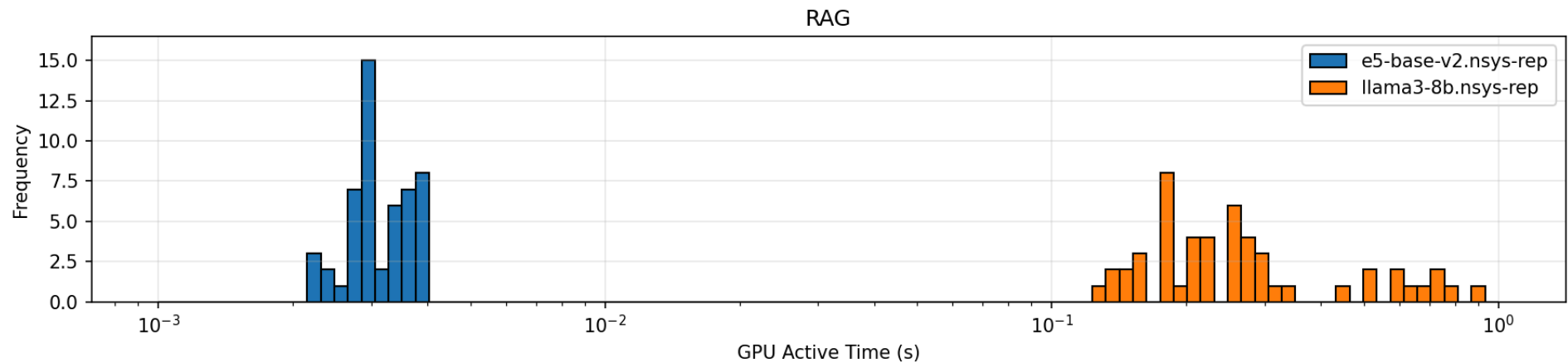
- K8S default behavior:
 - One model per GPU
 - Reactively scales based on queue sizes
 - Optimizes throughput, no latency awareness
 - Only explores the data parallel dimension

Critical-path Aware Parallelism

- K8S default behavior:
 - One model per GPU
 - Reactively scales based on queue sizes
 - Optimizes throughput, no latency awareness
 - Only explores the data parallel dimension
- We can do better

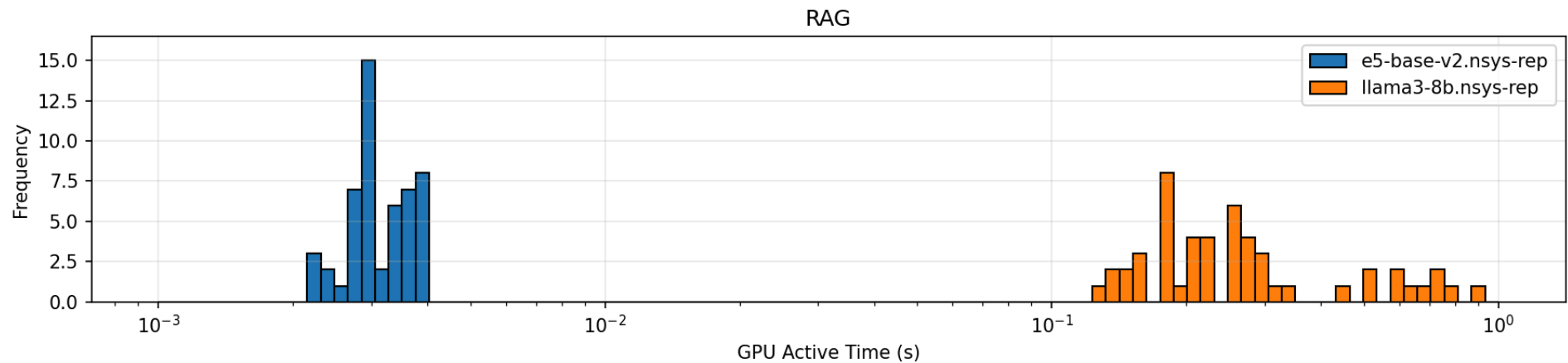
Critical-path Aware Parallelism

- K8S default behavior:
 - One model per GPU
 - Reactively scales based on queue sizes
 - Optimizes throughput, no latency awareness
 - Only explores the data parallel dimension
- We can do better



Critical-path Aware Parallelism

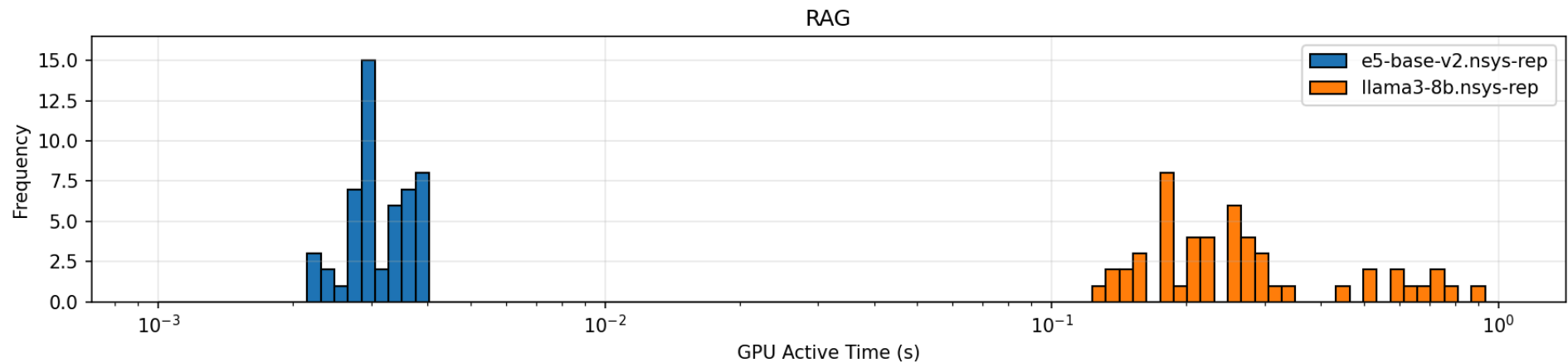
- K8S default behavior:
 - One model per GPU
 - Reactively scales based on queue sizes
 - Optimizes throughput, no latency awareness
 - Only explores the data parallel dimension
- We can do better



- LLM latency 100x embedding latency

Critical-path Aware Parallelism

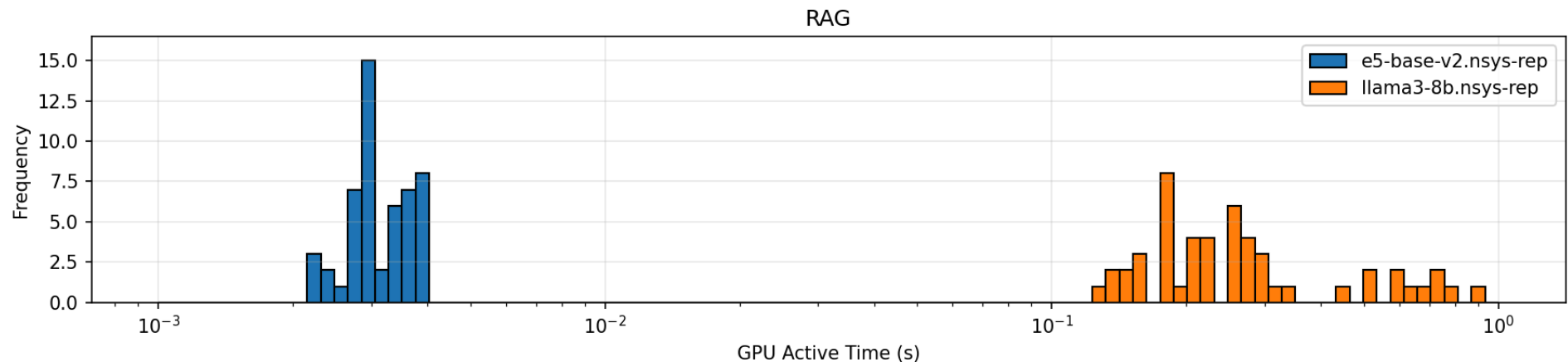
- K8S default behavior:
 - One model per GPU
 - Reactively scales based on queue sizes
 - Optimizes throughput, no latency awareness
 - Only explores the data parallel dimension
- We can do better



- LLM latency 100x embedding latency
- LLM is the critical path

Critical-path Aware Parallelism

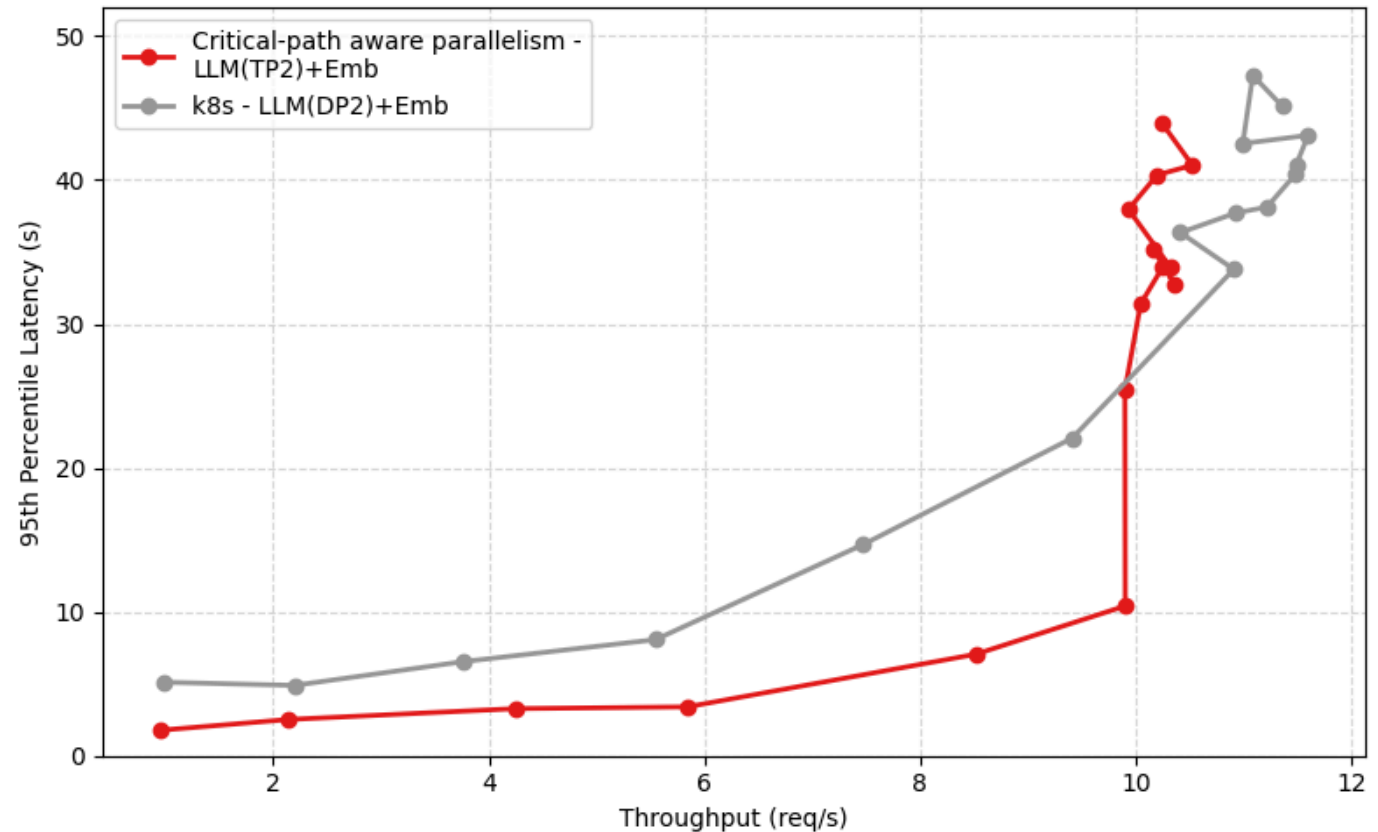
- K8S default behavior:
 - One model per GPU
 - Reactively scales based on queue sizes
 - Optimizes throughput, no latency awareness
 - Only explores the data parallel dimension
- We can do better



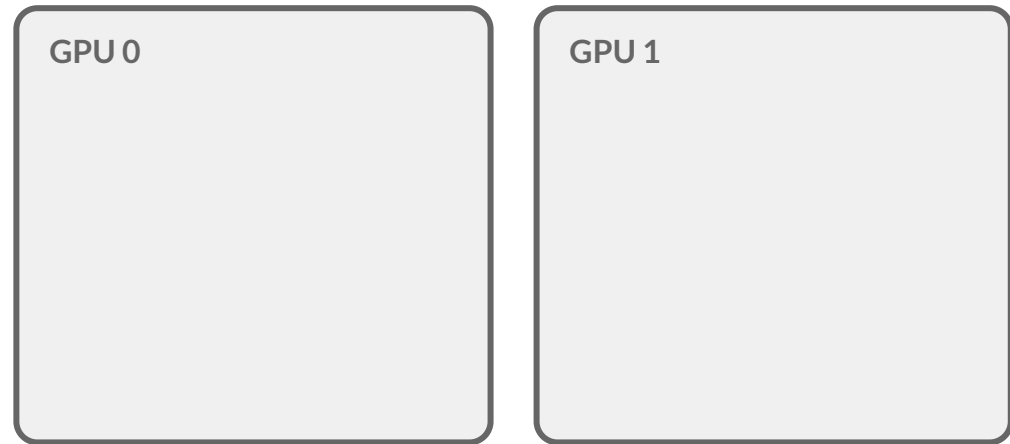
- LLM latency 100x embedding latency
- LLM is the critical path
- TP2 halves RAG application latency

Critical-path Aware Parallelism

- **2.4x** improvement in latency
- Minor degradation in throughput

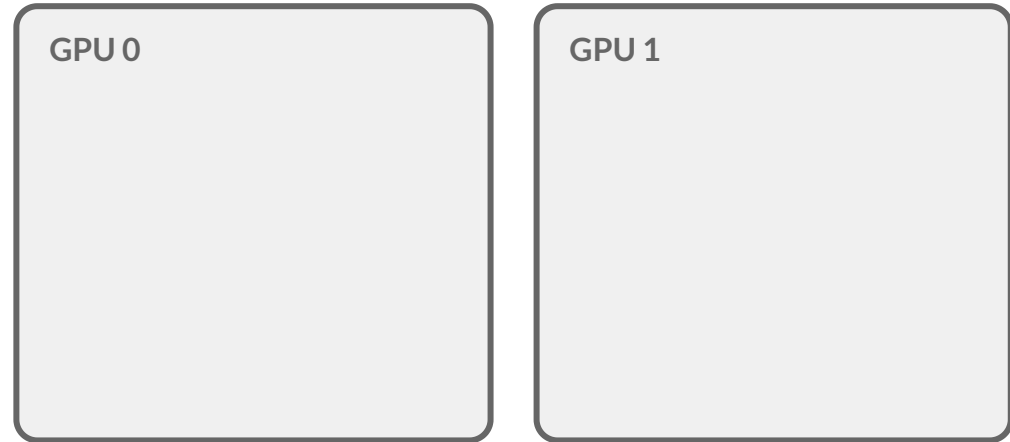


Critical-path Aware Co-location



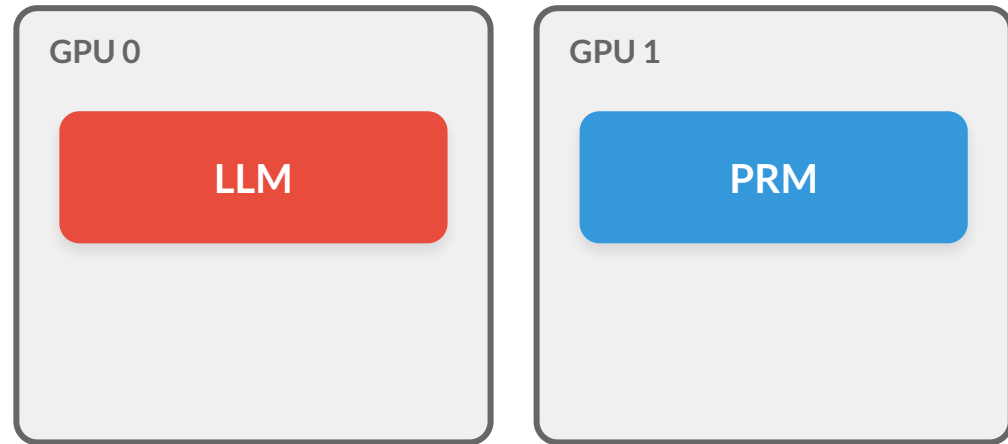
Critical-path Aware Co-location

- How should we deploy this application?



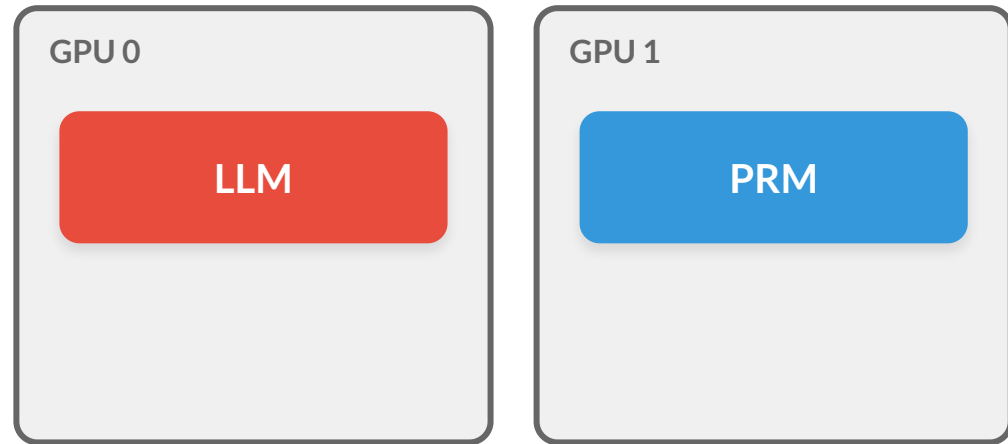
Critical-path Aware Co-location

- How should we deploy this application?

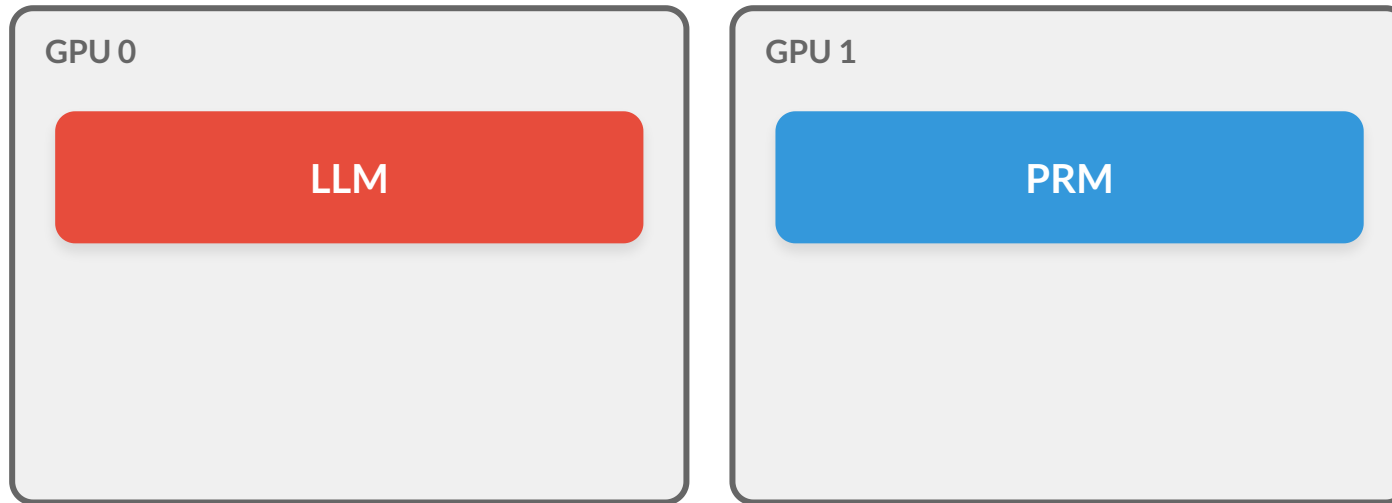


Critical-path Aware Co-location

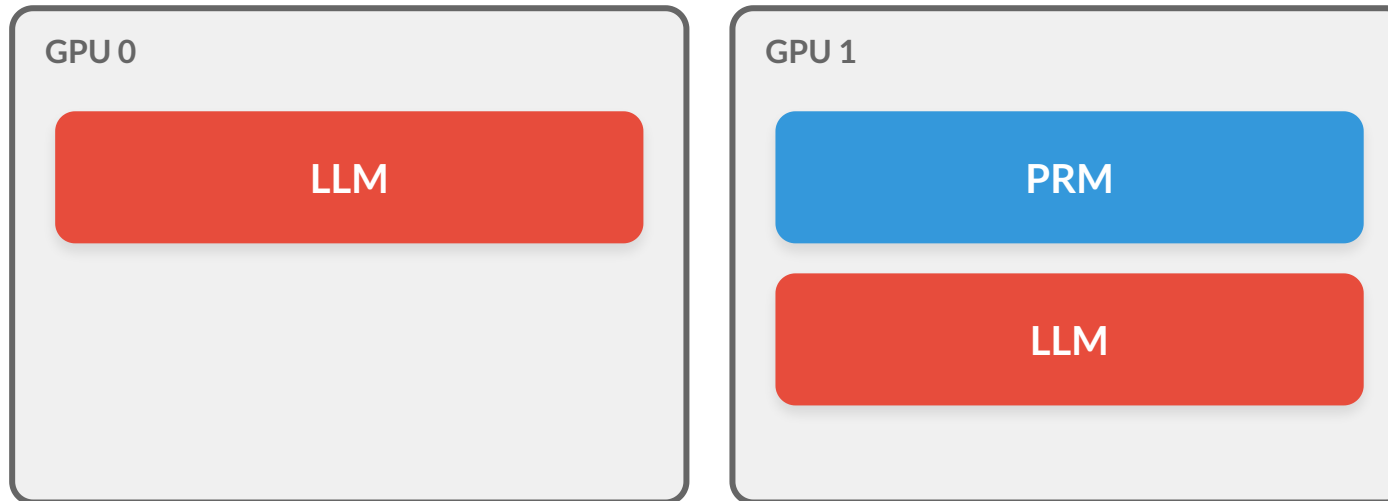
- How should we deploy this application?
- Severe underutilization



Critical-path Aware Co-location

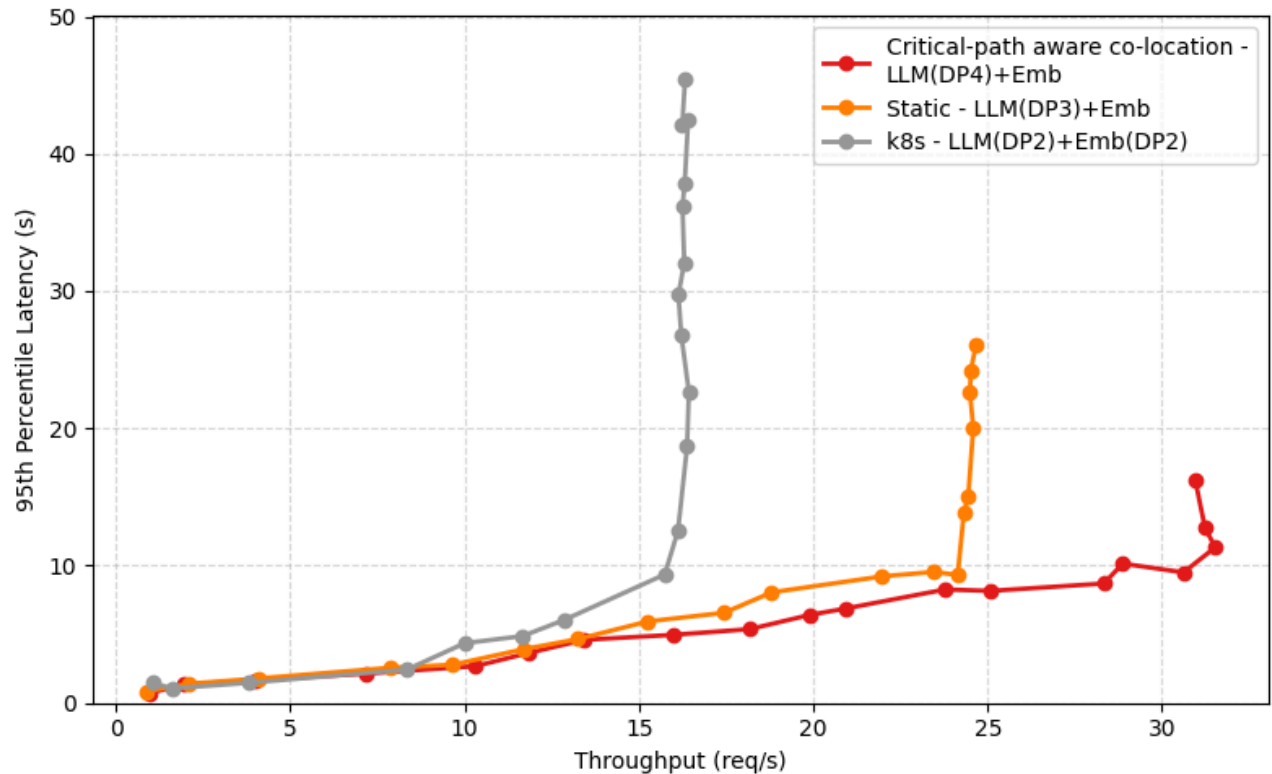


Critical-path Aware Co-location

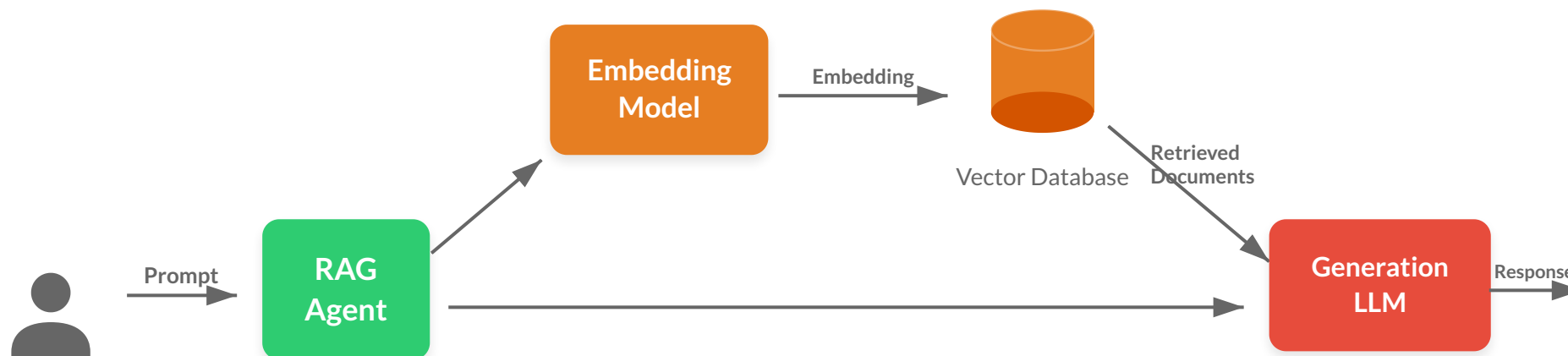


Critical-path Aware Co-location

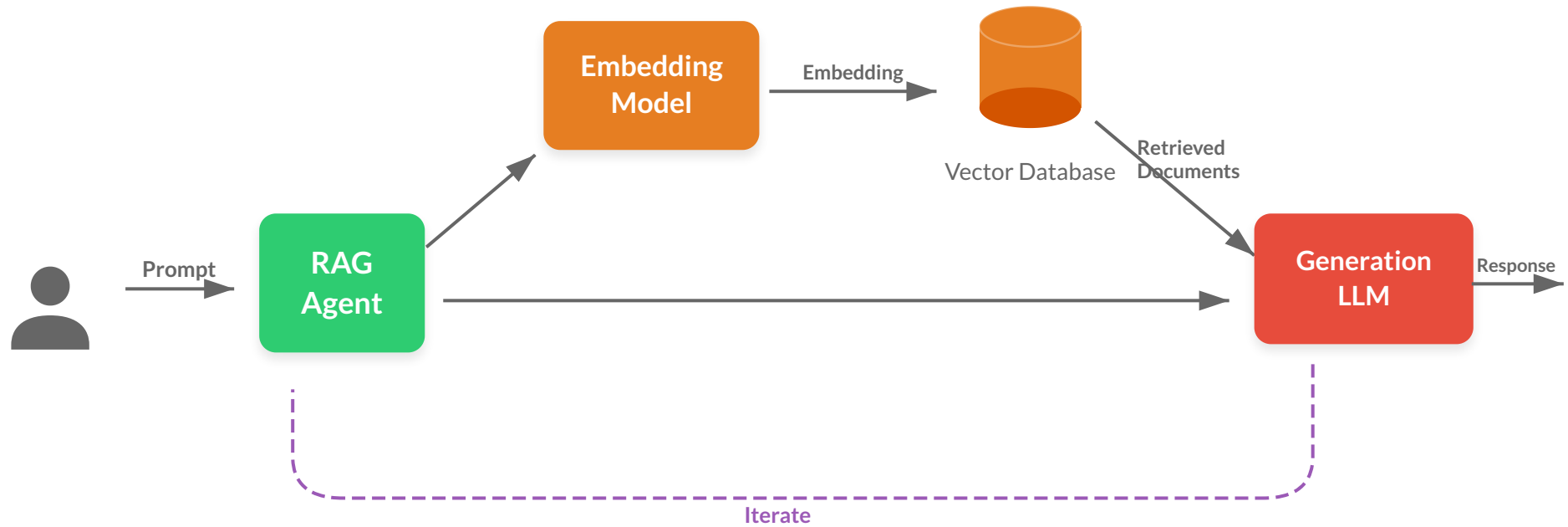
- 2x throughput over K8S
- 50% over best manual K8S config
- K8S: data parallelism only



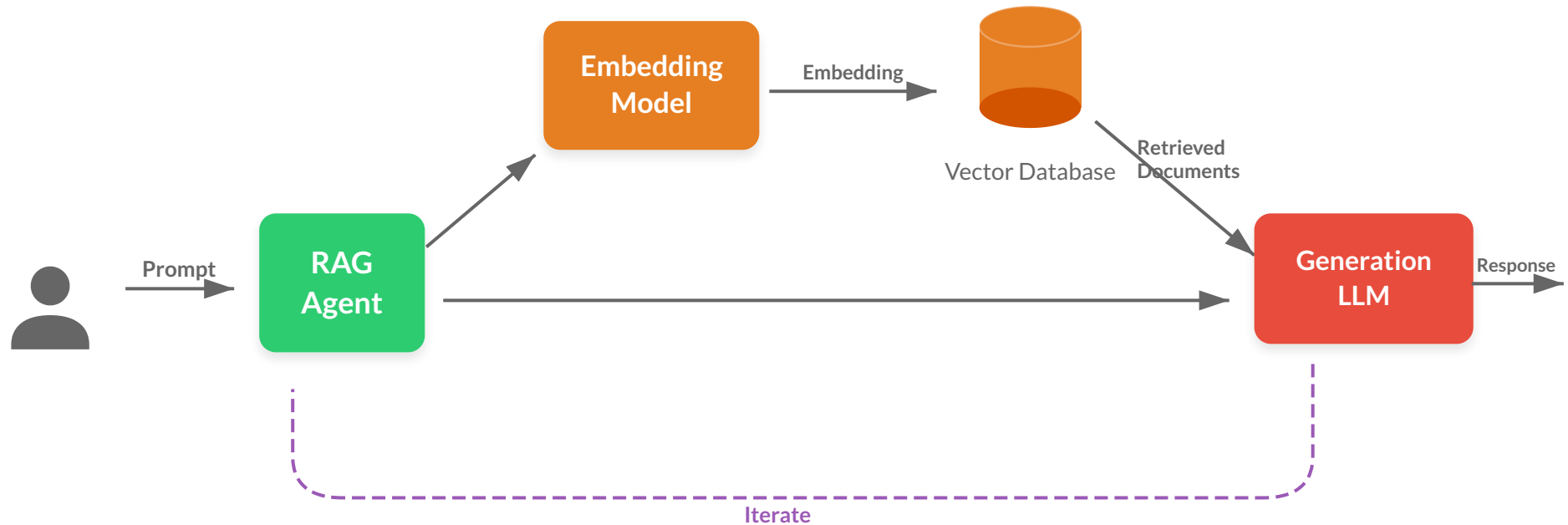
Future Work: Multi-Engine Fairness



Future Work: Multi-Engine Fairness

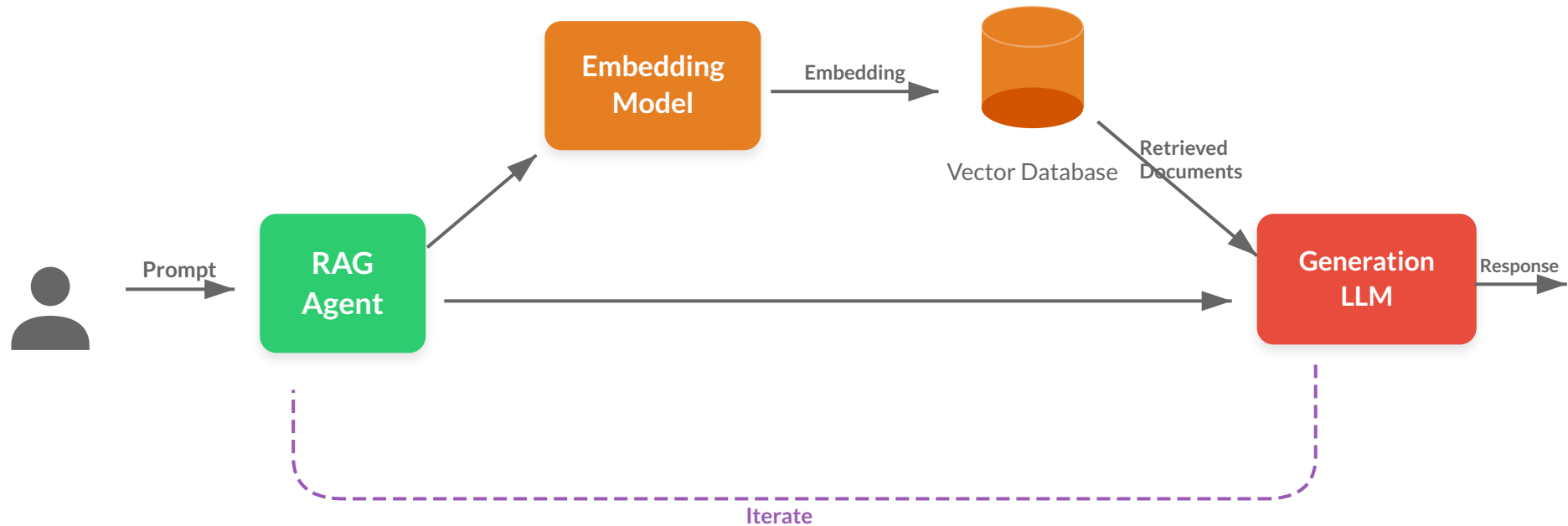


Future Work: Multi-Engine Fairness



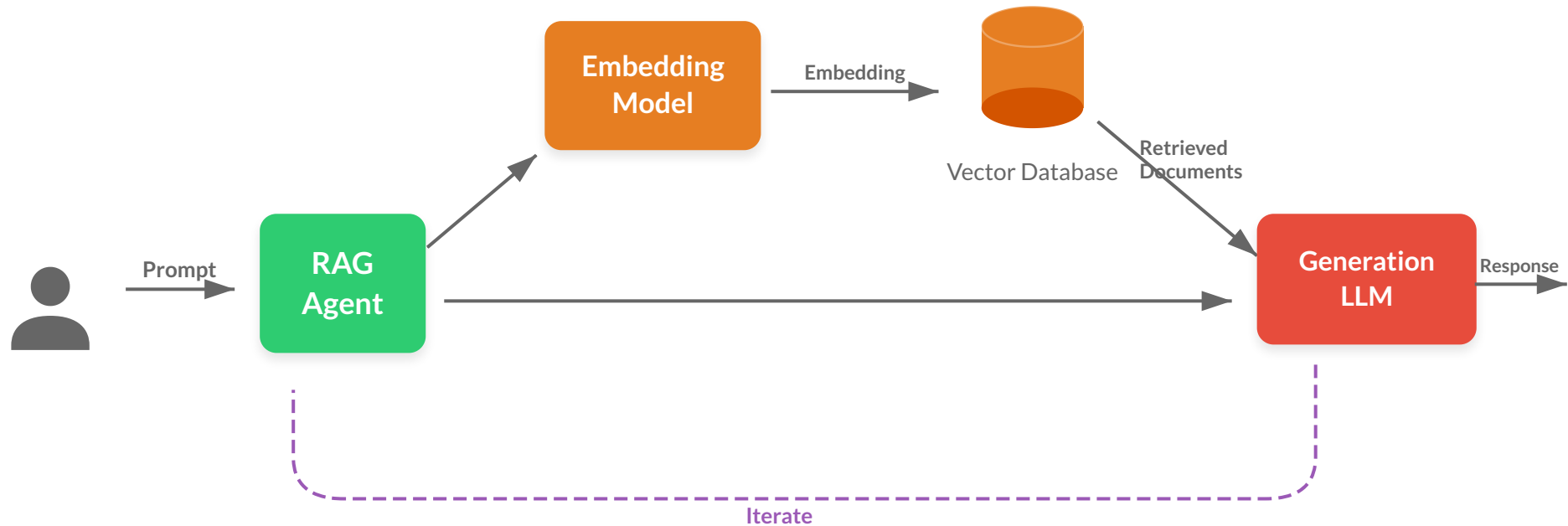
- Common pattern in agentic applications

Future Work: Multi-Engine Fairness



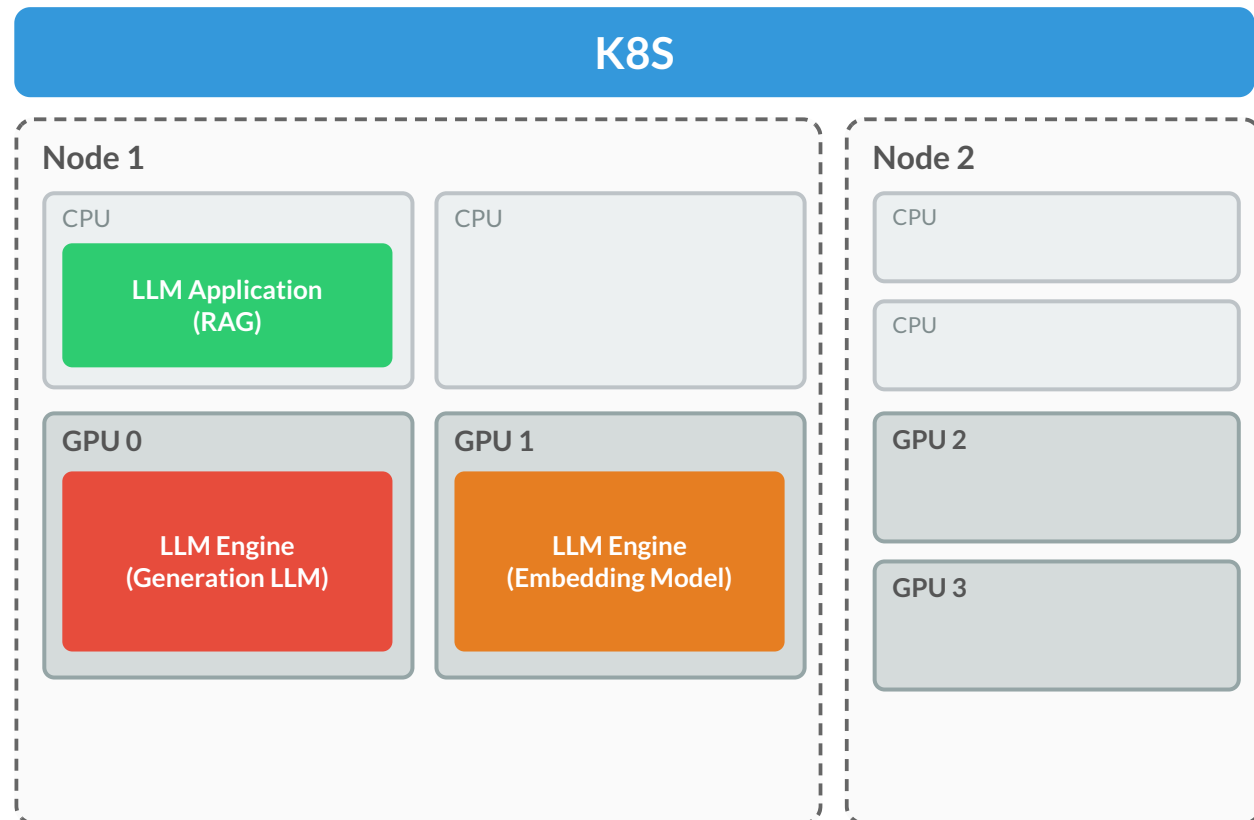
- Common pattern in agentic applications
- Some requests far more expensive than others

Future Work: Multi-Engine Fairness



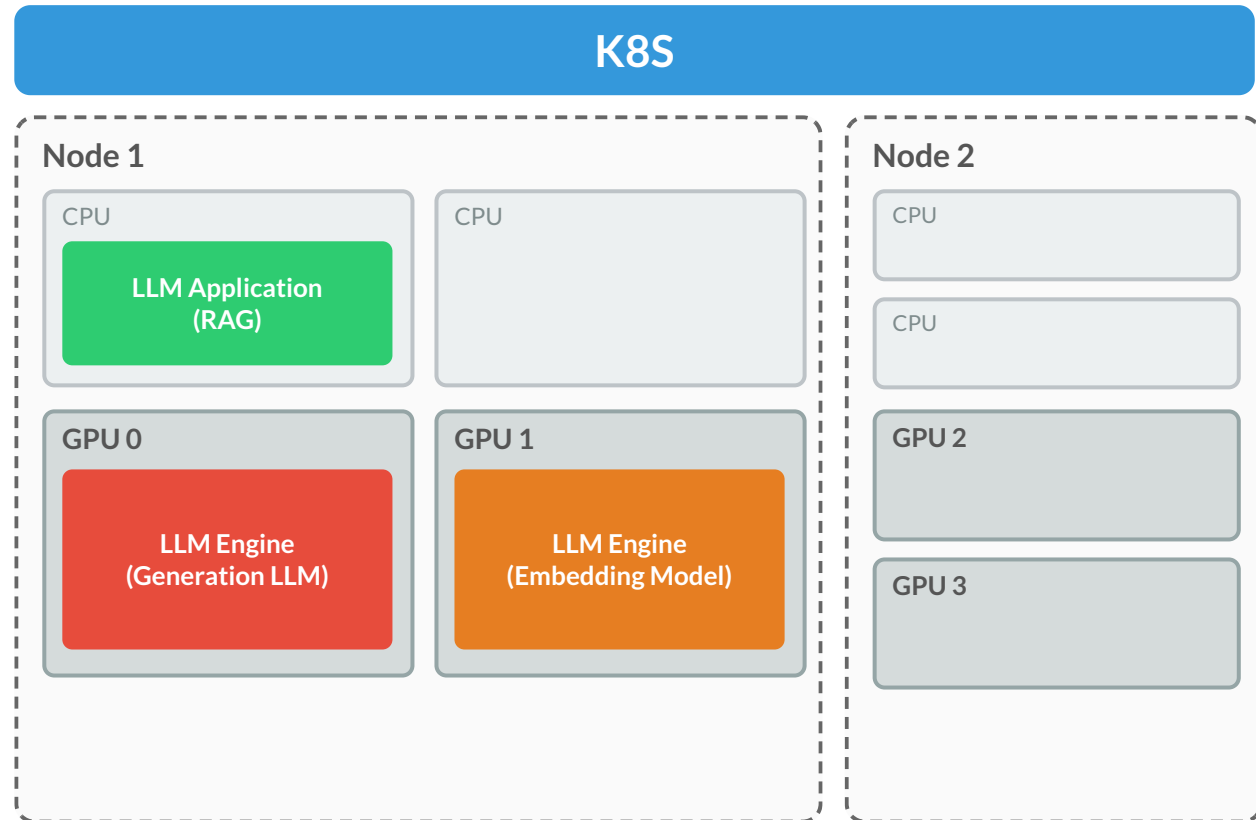
- Common pattern in agentic applications
- Some requests far more expensive than others
- HoL blocking for the many cheaper requests that iterate fewer times

Future work: Multi-Engine Fairness



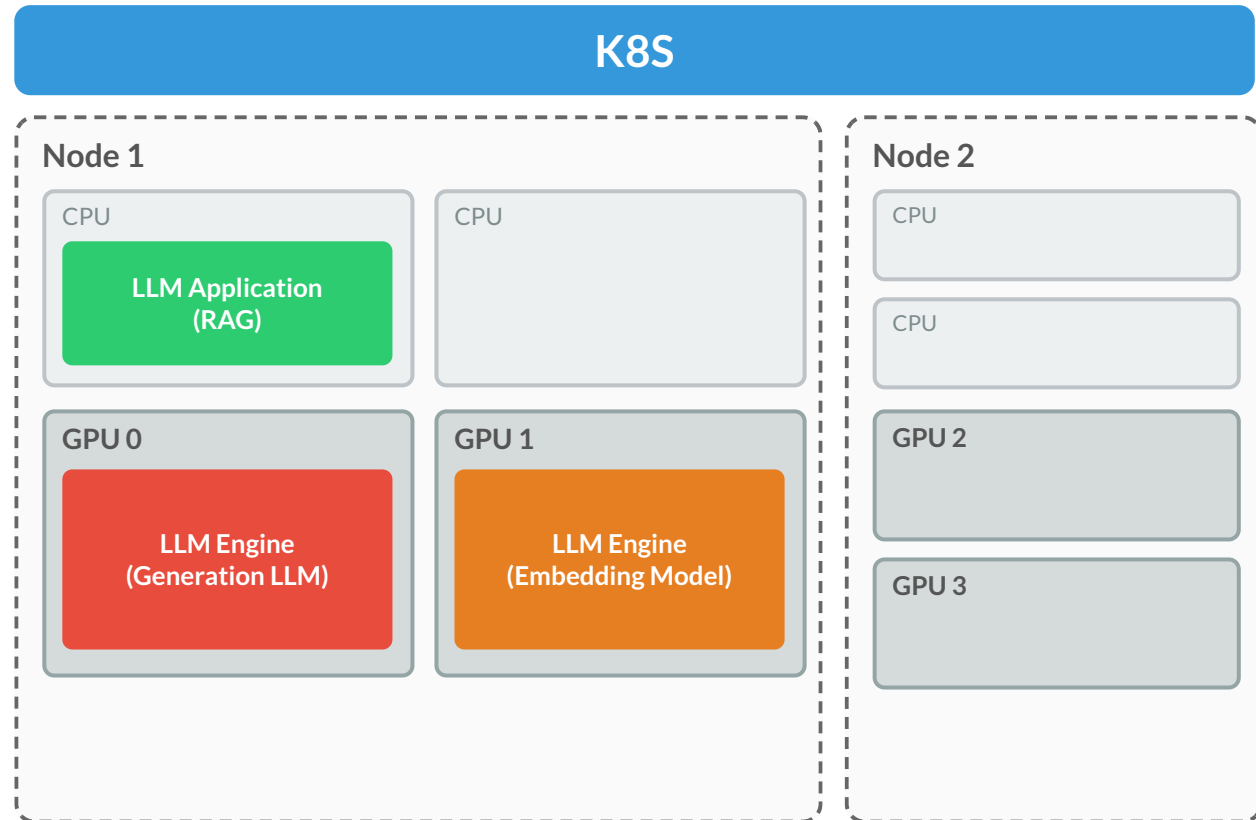
Future work: Multi-Engine Fairness

- Current approaches only mitigate HoL blocking for single engine



Future work: Multi-Engine Fairness

- Current approaches only mitigate HoL blocking for single engine
- Applications can span multiple engines



Future work: Multi-Engine Fairness

- Current approaches only mitigate HoL blocking for single engine
- Applications can span multiple engines
- Can also have HoL blocking between workflows

