Deploying AI

Optimization and System Design

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$ echo "Data Sciences Institute"
```

Introduction

Agenda

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- Inference optimization
- AI engineering architecture
- User feedback

Software Products with Embedded AI

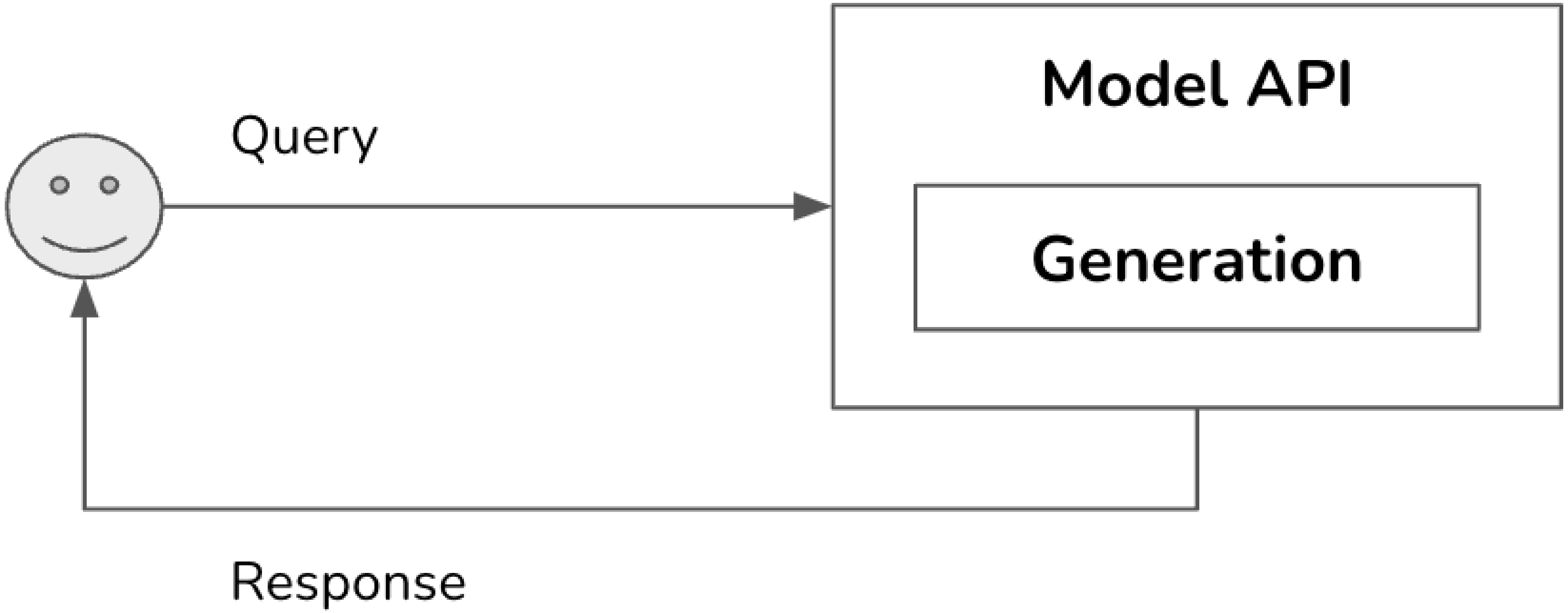
AI models have become generally available through general-purpose software:

- Generate images, illustrations and video
- Generate and rewrite text
- Summarize documents and calls
- Gather data
- Review and Write Code

Initial Stage: Interaction through LLMs Embedded in General Purpose Software

- The simplest form of implementation is to acquire software with embedded AI (MS Copilot, ChatGPT, etc).
- Simple mode of operation.
- Low barriers to entry diminish the competitive advantage.
- Guidelines and policies have limited effect over risk exposure.

Initial Stage



Challenges in Building Production-Level Applications with LLM (1/2)

Using LLMs:

- It is easy to create a cool prototype, but difficult to create production-ready software.
- LLM limitations are exacerbated:
    - Lack of engineering rigor in prompt engineering.
    - Natural language can be ambiguous.
    - It is a newly created field.

Challenges in Building Production-Level Applications with LLM (2/2)

- Ambiguity occurs in the way prompts are written (by human) and how they are interpreted (by LLM). For example:
  - Ambiguous output format: downstream applications expect outputs in a certain format, which LLMs do not necessarily provide consistently.
  - Inconsistency in user experience: LLMs are stochastic, there is no guarantee that the model will provide the same output given the same input every time.

Areas of Enhancement

- Enhance context input into the model: give the model access to (external) data sources and tools for information gathering.
- Set up guardrails: protect systems and users.
- Add model router and gateway: support complex pipelines and security.
- Add cache: optimize for latency and cost.
- Add complex logic and write actions to maximize capabilities.

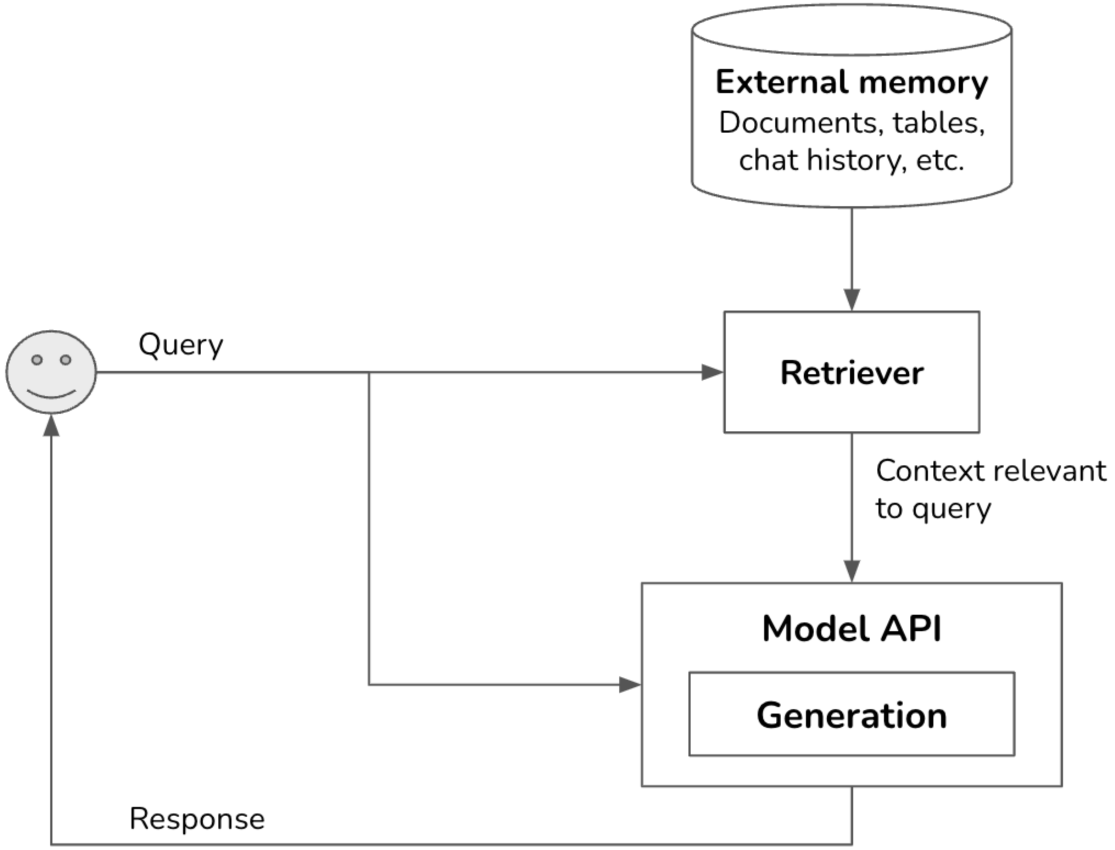
Performance-Driven Development

Although FMs are a recent evolution in modelling, the principles of building AI enterprise applications remain the same:

- Map business metrics to AI metrics.
- Systematic experimentation.
- Experiment with different prompts (equivalent to hyperparameter tuning).
- Optimize for performance, latency, and cost.
- Set up feedback loops to iteratively improve our applications.

Retrieval-Augmented Generation (RAG)

- Similar to feature engineering in ML, RAG augments each query with necessary information.
- Context construction: gather the relevant information for the query.
- The more context provided to the model, the less it needs to rely on its training.
- In-context learning is a form of continual learning. It delays a model from being outdated by continually incorporating new information.


External memory
Documents, tables, chat history, etc.
Query
Retriever
Context relevant to query
Model API
Generation
Response

Add Guardrails (1/3)

Input guardrails

- The risk of exposing sensitive or private data to external vendors via external model APIs arises.
- Some guardrails include obfuscating personal information (ID numbers, phone, bank accounts, etc.), human faces, specific labels, keywords, and phrases that identify sensitive information.

Add Guardrails (2/3)

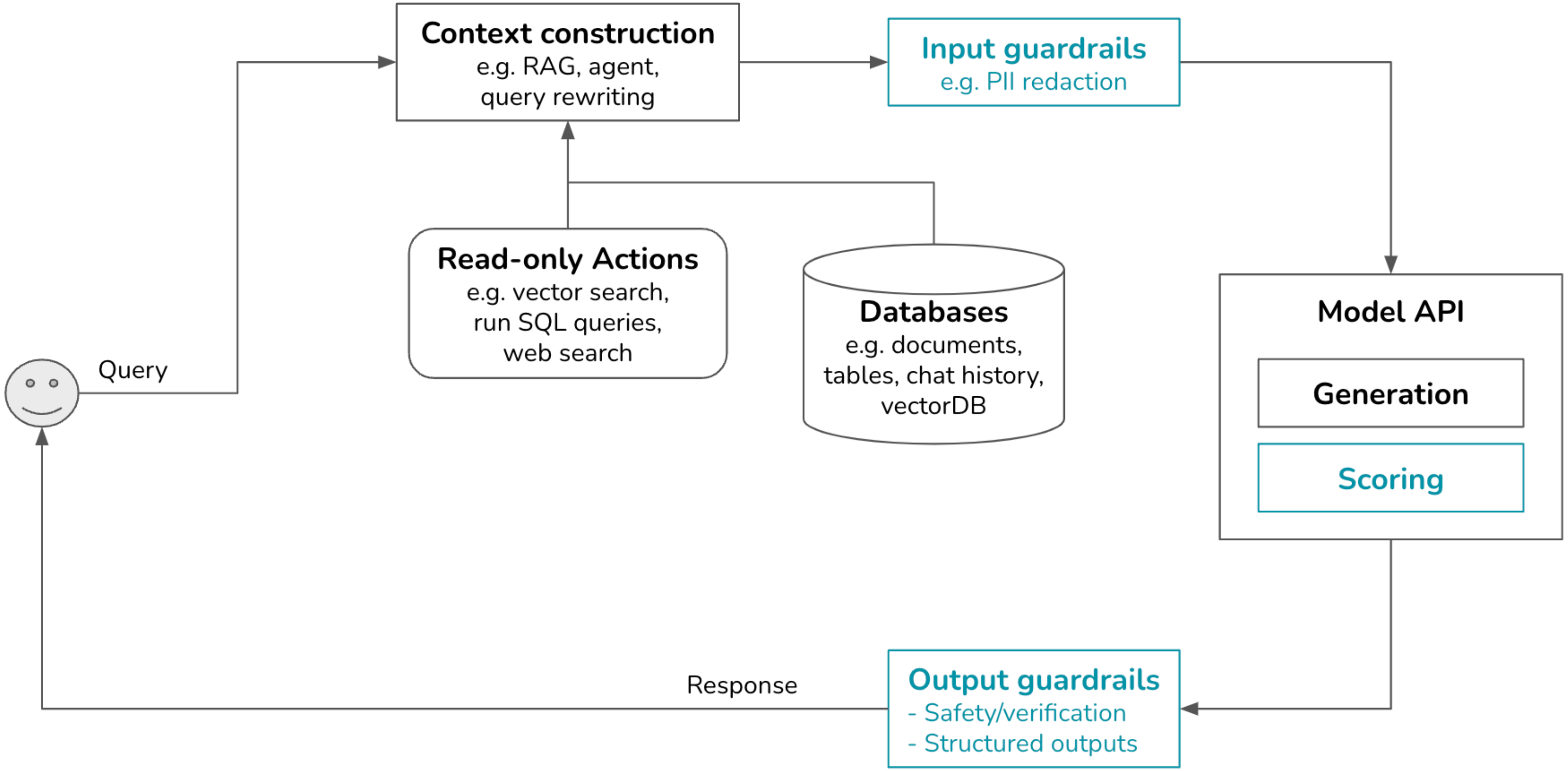
Model jailbreaking:

- Preclude the model from executing queries that can be harmful.
- Ex.: no SQL queries.

Add Guardrails (3/3)

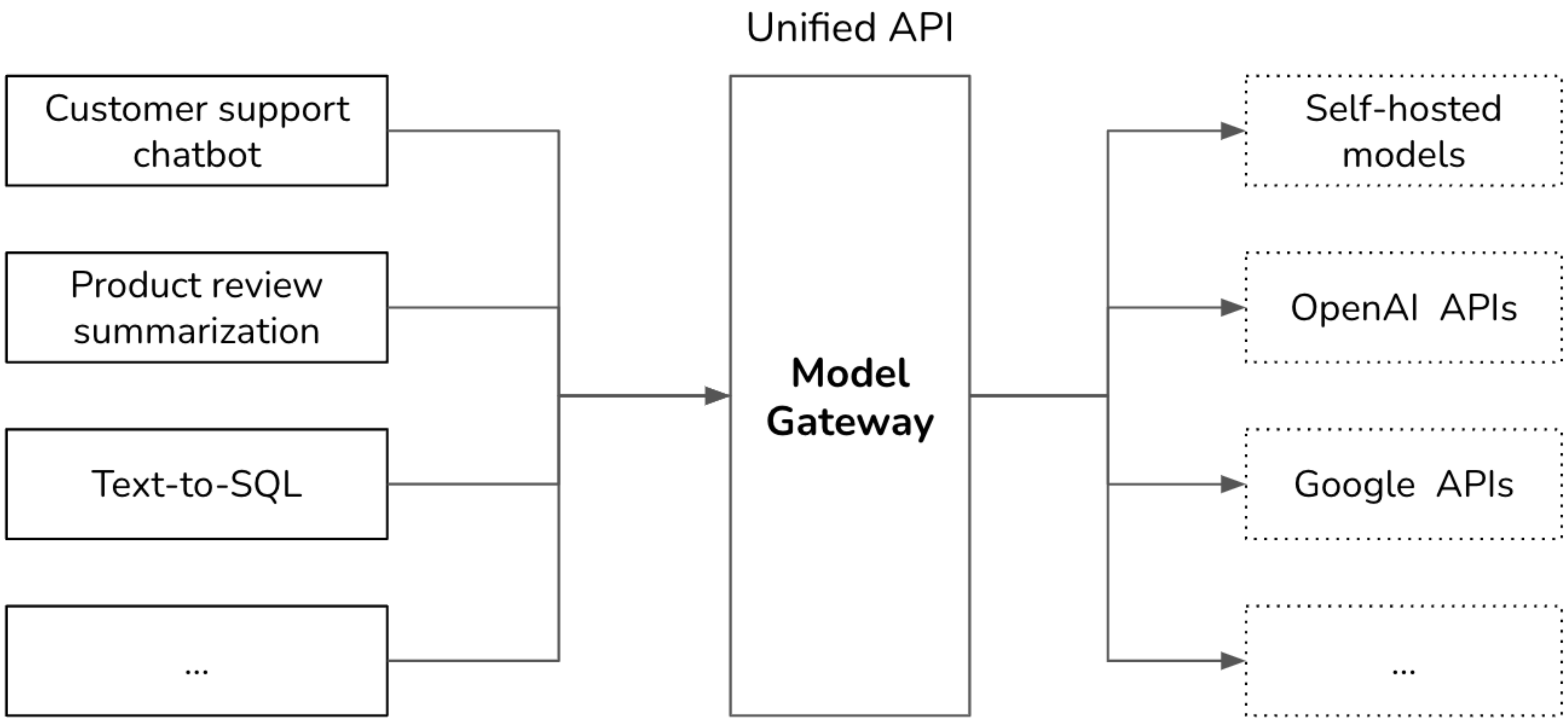
Output guardrails

- Evaluate the quality of each generation, including empty responses, malformatted responses, toxic responses, factual inconsistent responses, responses that contain sensitive information, and brand-risk responses.
- Specify the policy to deal with different failure modes.


Context construction
e.g. RAG, agent,
query rewriting
Input guardrails
e.g. PII redaction
Read-only Actions
e.g. vector search,
run SQL queries,
web search
Databases
e.g. documents,
tables, chat history,
vectorDB
Model API
Generation
Scoring
Query
Response
Output guardrails
- Safety/verification
- Structured outputs

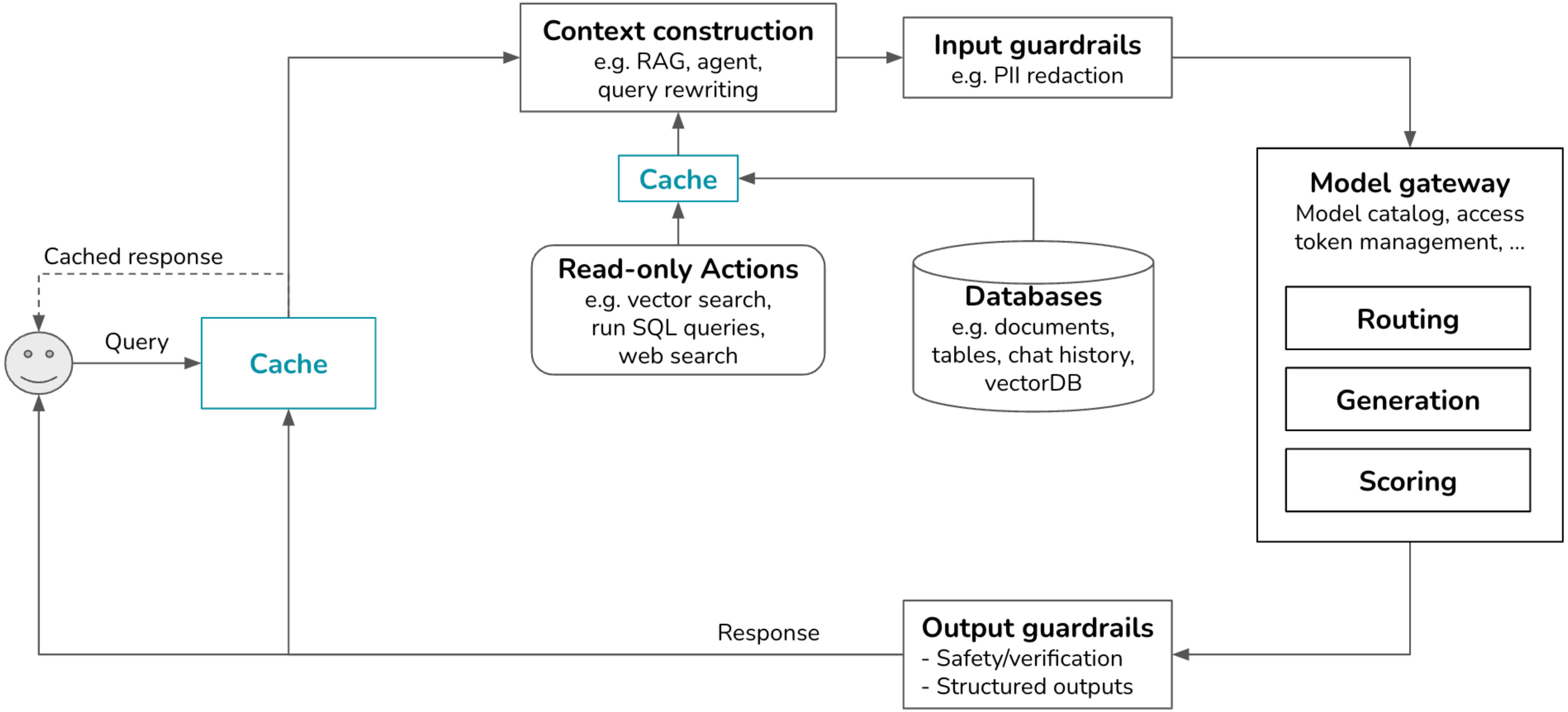
Add Model Router and Gateway

- A model router selects the best suitable model for the job:
  - An intent classifier predicts what the user is trying to do.
  - The right model is chosen for the task based on the predicted intent.
- An intent classifier can also preclude out-of-scope conversations.
- A model gateway allows the system to interface with different models in a unified and secure manner.


Unified API
Customer support chatbot
Product review summarization
Text-to-SQL
...
Model Gateway
Self-hosted models
OpenAI APIs
Google APIs
...

Caching

- Caching can significantly reduce latency and cost.
- Prompt cache:
  - Store overlapping segments for reuse.
  - Application with long system prompts or that involve long documents.
- Exact cache:
  - Cache stores processed items for reuse later.
  - Can be used to reduce vector search in embedding-based retrieval.
- Semantic cache:
  - Determines semantic similarity between queries.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Cache
Cached response
Query
Cache
Read-only Actions
e.g. vector search,
run SQL queries,
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Databases
e.g. documents,
tables, chat history,
vectorDB
Model gateway
Model catalog, access
token management, ...
Routing
Generation
Scoring
Response
Output guardrails
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References

References

- Huyen, Chip. Designing machine learning systems. O'Reilly Media, Inc., 2022