Retrieval-Augmented Generation

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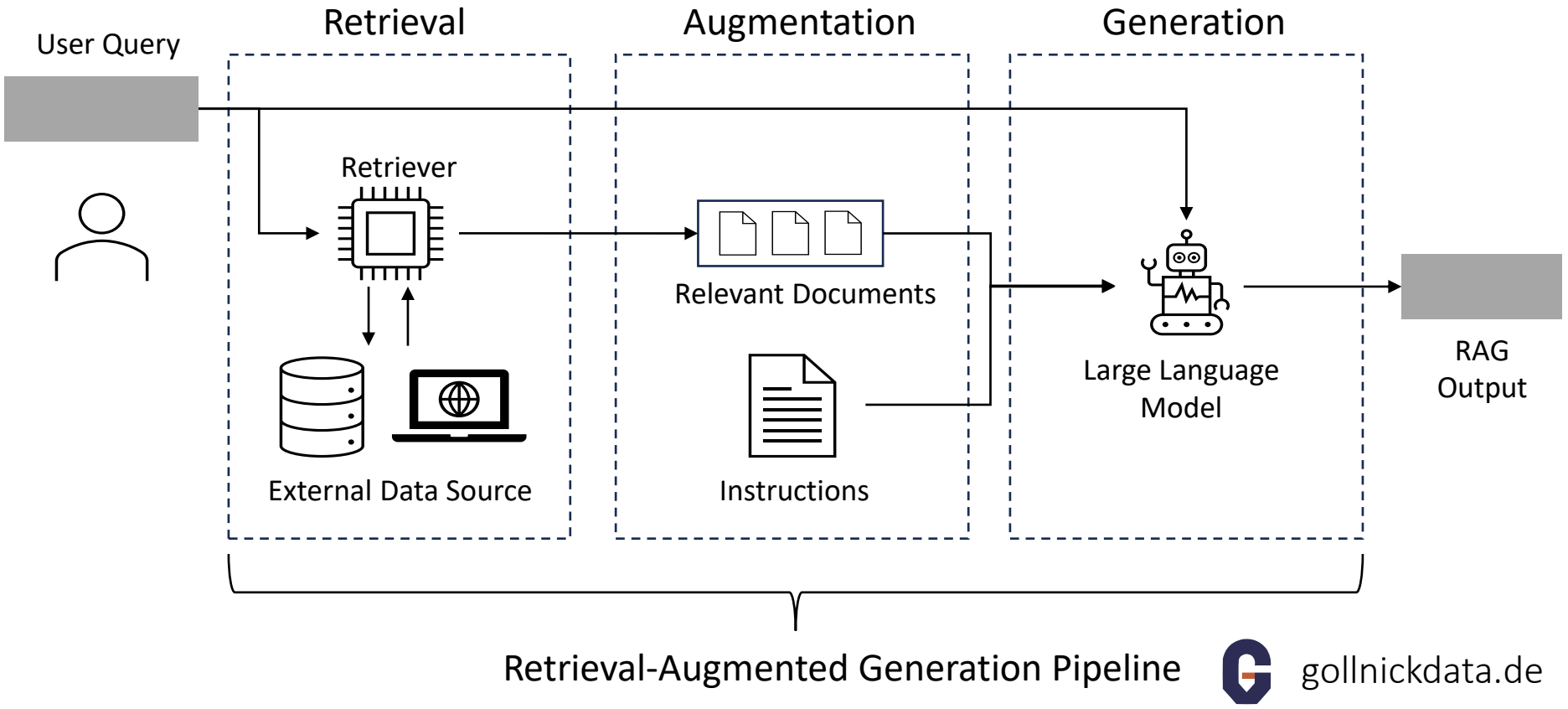
Retrieval-Augmented Generation:

General Workflow

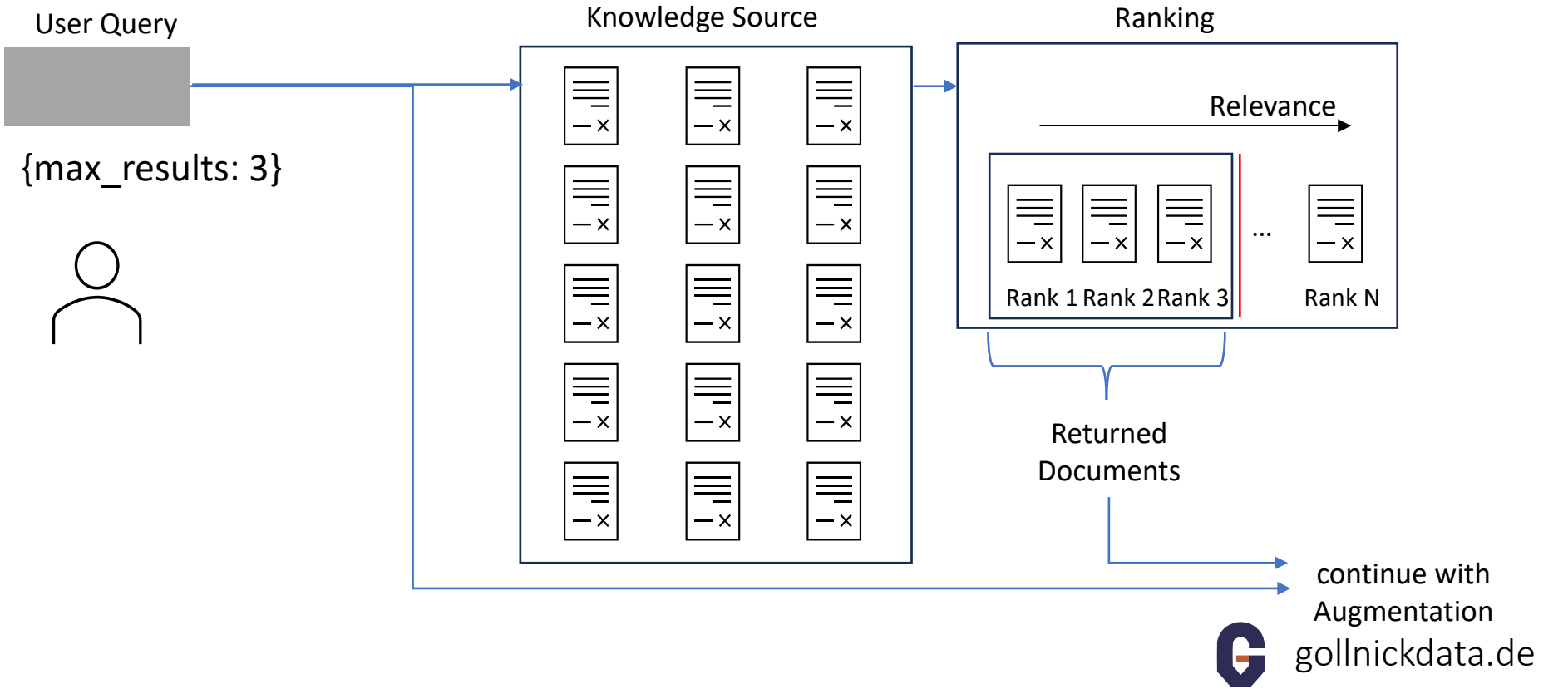
Retrieval-Augmented Generation

General Workflow



Retrieval-Augmented Generation

Retrieval Process

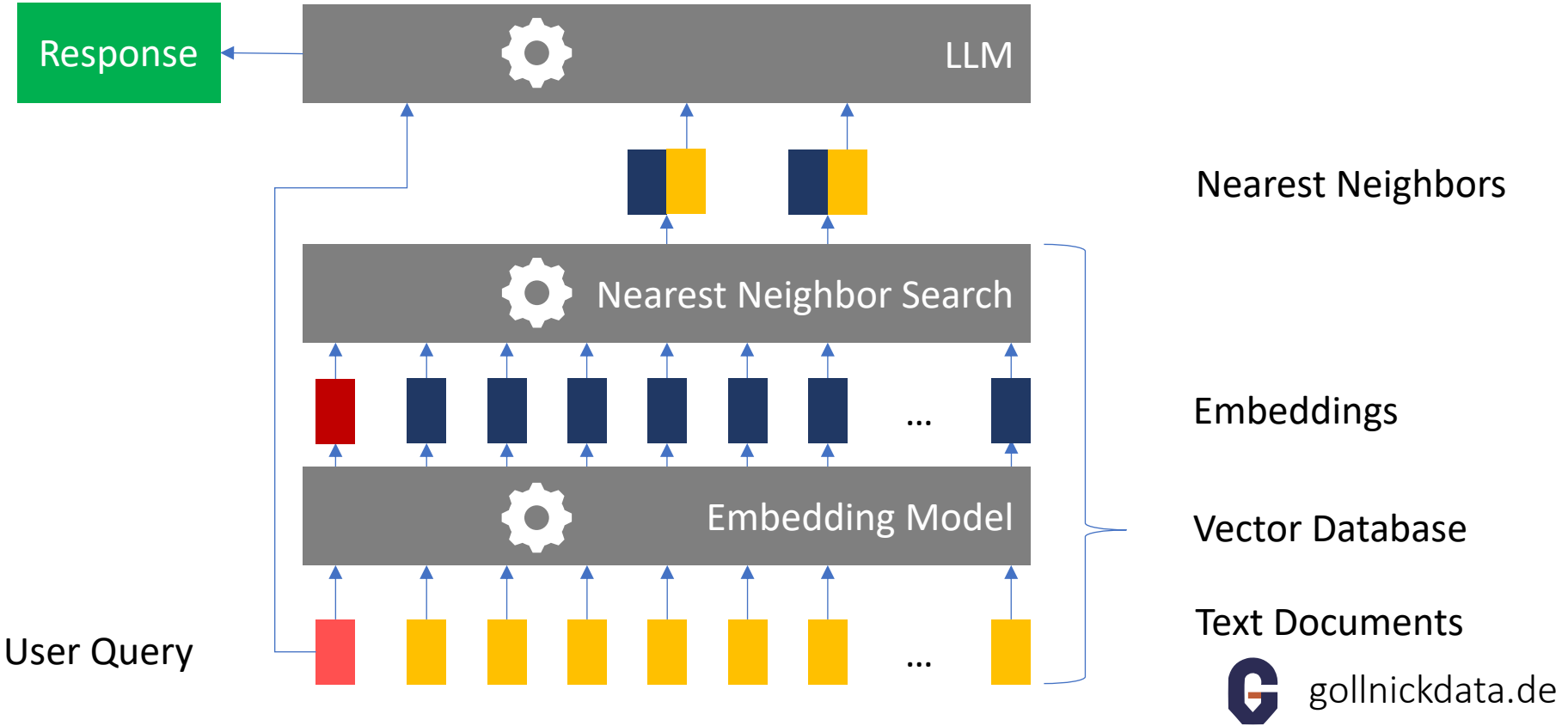


Retrieval-Augmented Generation:

Simple RAG

Retrieval-Augmented Generation

Workflow with Vector DB Backend

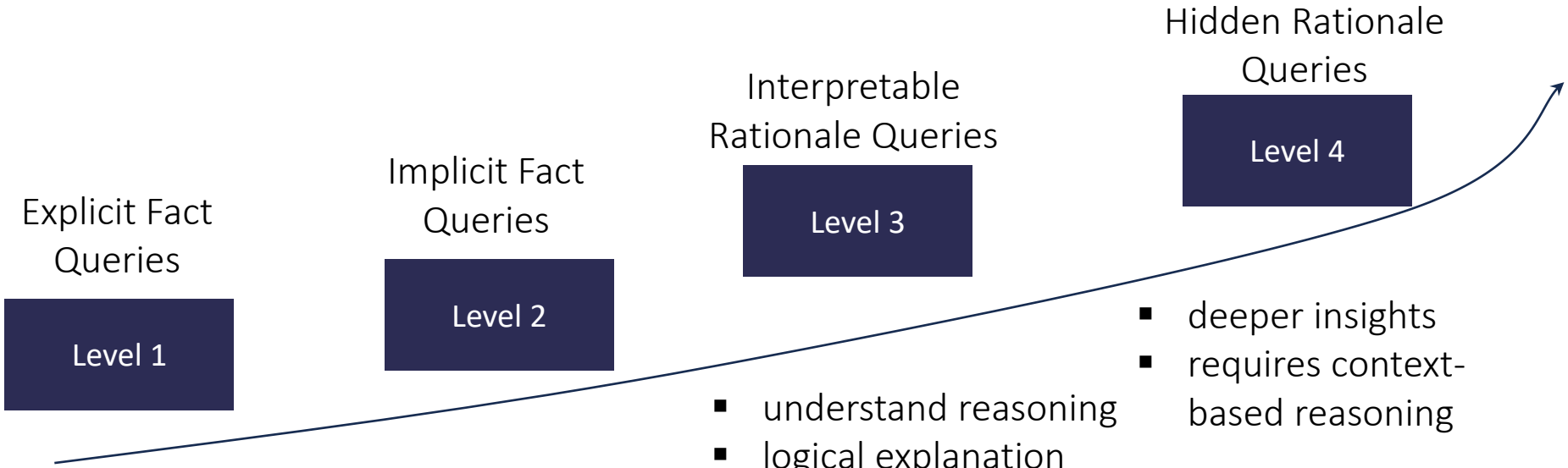


Retrieval-Augmented Generation:

RAG Improvements for Pre-Retrieval

Retrieval-Augmented Generation

Levels of RAG



- known facts
- no reasoning

What is the majority party in Germany?

- known facts
- interpretation needed to identify answer

What is the majority party in the country where Berlin is located?

- understand reasoning
- logical explanation

- deeper insights
- requires context-based reasoning

Source:
https://arxiv.org/pdf/2409.14924

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Retrieval-Augmented Generation

RAG Improvement for Pre-Retrieval, Retrieval, and Post-Retrieval

Pre-Retrieval

- improve indexing pipeline

Retrieval

- improve retrieval process

Post-Retrieval

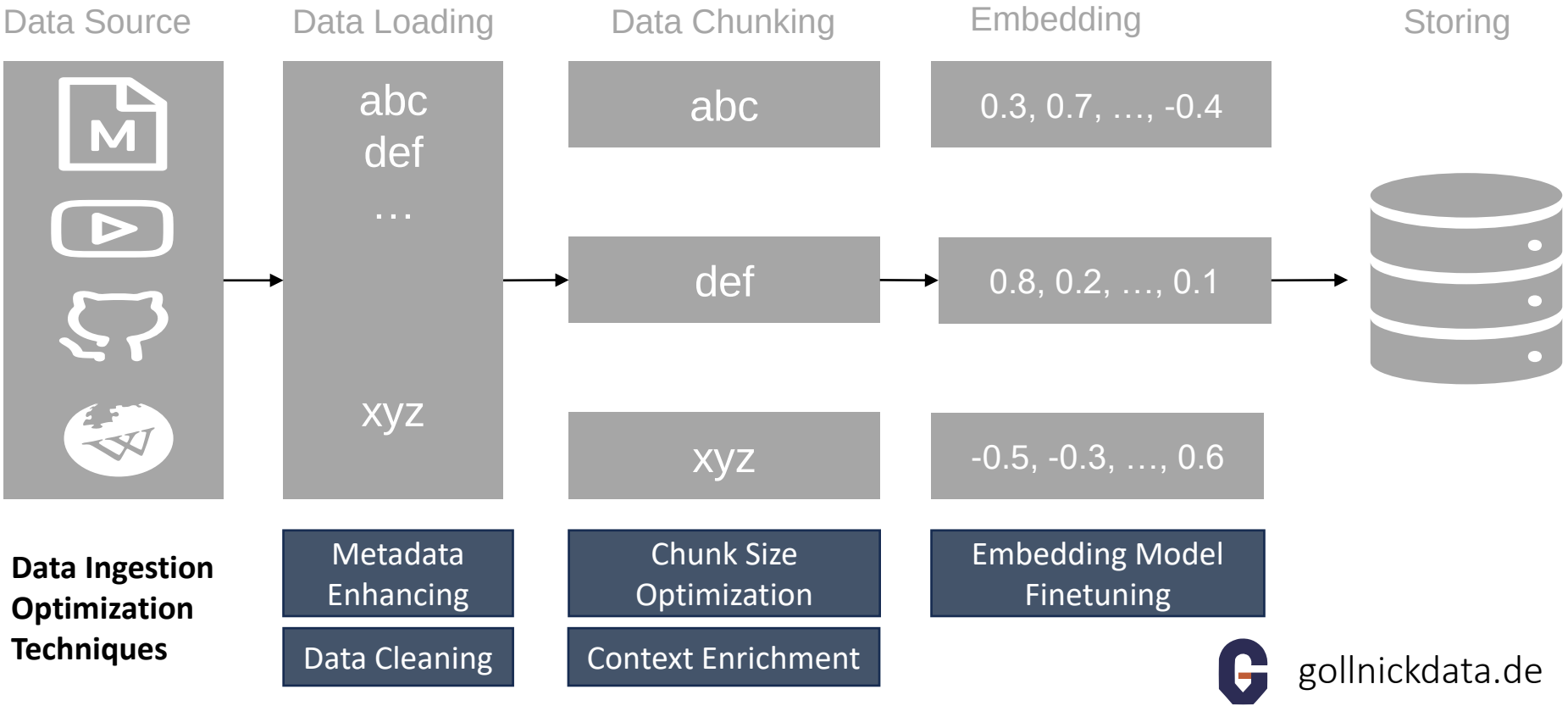
- improve user query

Retrieval-Augmented Generation:

RAG Improvements for Pre-Retrieval

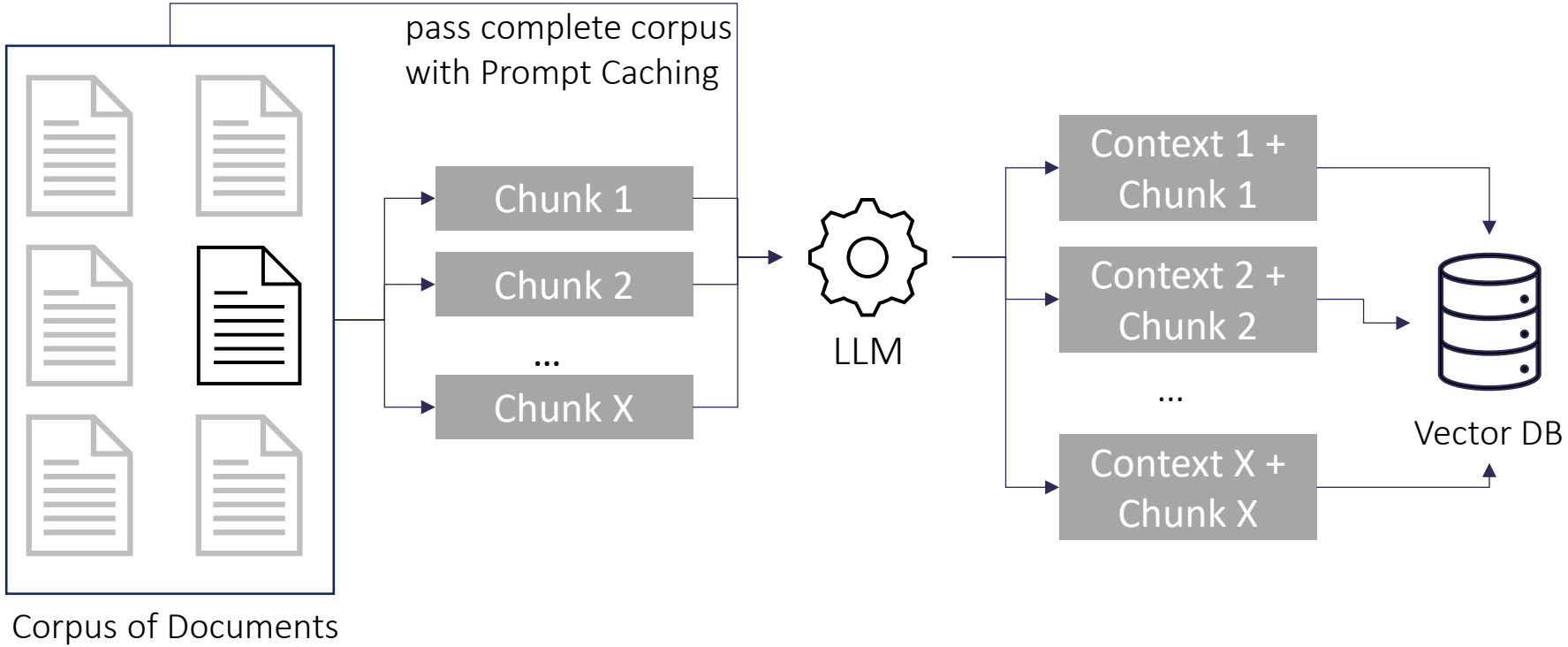
Retrieval-Augmented Generation

RAG Improvement Approaches Pre-Retrieval



Retrieval-Augmented Generation

RAG Improvement for Pre-Retrieval: Context Enrichment with Contextual Retriever



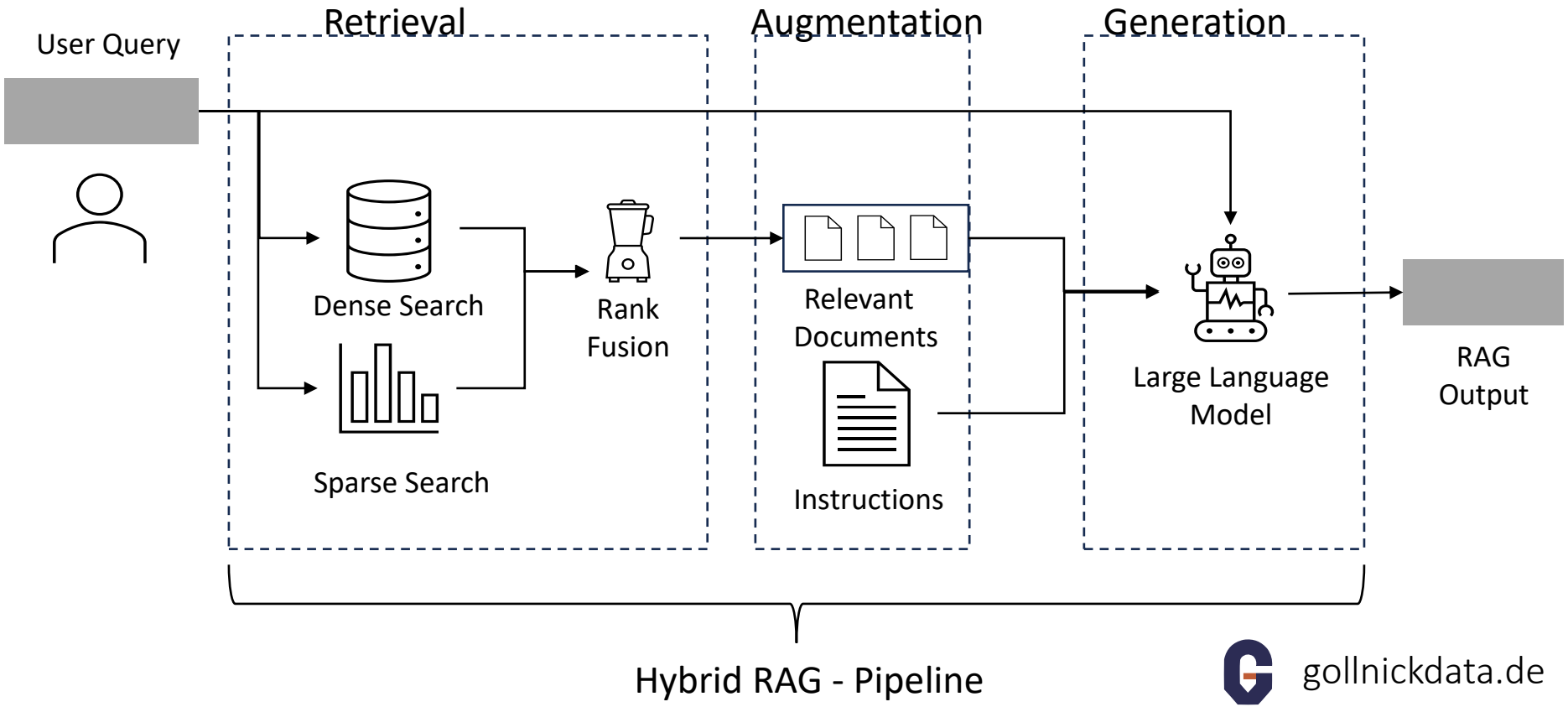
own graph; adapted from https://www.anthropic.com/news/contextual-retrieval

Retrieval-Augmented Generation:

RAG Improvements for Retrieval

Retrieval-Augmented Generation

RAG Improvement for Retrieval: Hybrid RAG



Retrieval-Augmented Generation

Reciprocal Rank Fusion

Rank	Dense Search Result	Sparse Search Result	Reciprocal Rank
1	Document D	Document A	1/1
2	Document A	Document C	1/2
3	Document C	Document B	1/3
4	Document B	Document D	1/4

a) Reciprocal Rank Calculation

Document A	1/2 + 1/1 = 1.5
Document D	1/1 + 1/4 = 1.25
Document C	1/3 + 1/2 = 0.83
Document B	1/4 + 1/3 = 0.58

b) Reciprocal Rank Fusion

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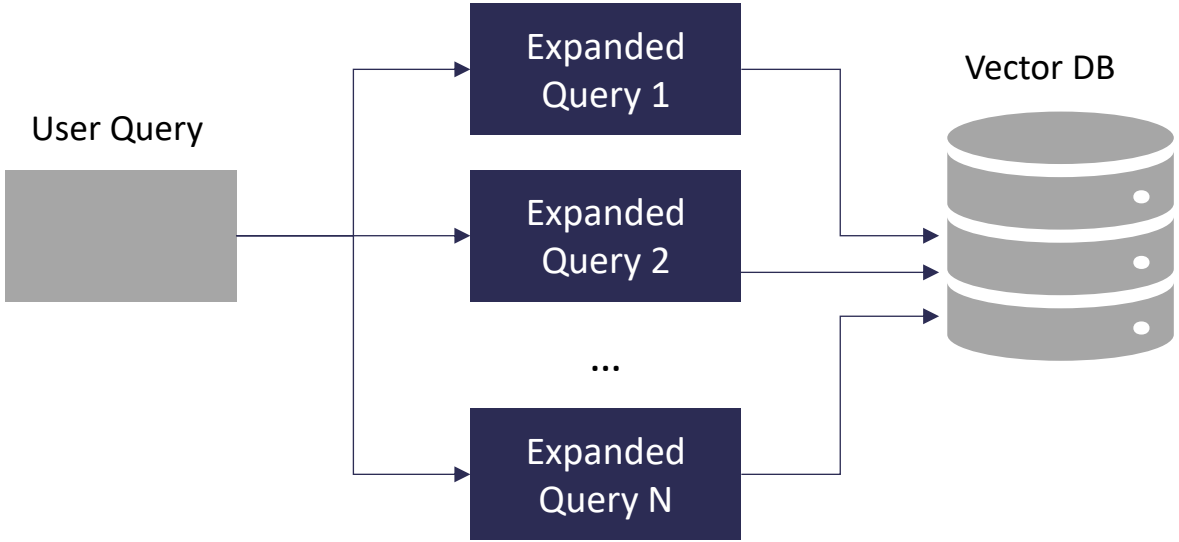
Retrieval-Augmented Generation

RAG Improvement for Retrieval: Query Expansion



Retrieval-Augmented Generation

RAG Improvement for Retrieval: Query Expansion

Synonym Expansion

expand with synonyms
“Climate change” →
[“global warming”,
“climate change”,
“environmental impact”]

Related Terms Expansion

related terms
“Machine learning” →
[“machine learning”,
“deep learning”,
“artificial intelligence”, “neural networks”]

Conceptual Expansion

“Renewable energy” →
[“renewable energy”,
“solar power”,
“wind energy”,
“green technology”,
“sustainable energy”]

Retrieval-Augmented Generation

RAG Improvement for Retrieval: Query Expansion

Phrase Variation Expansion

including variations of how a concept might be phrased ensures retrieval from documents that use different wording to discuss the same idea.
“Health benefits of exercise” →
[“health benefits of physical activity”,
“exercise health benefits”,
“positive effects of exercise”]

Contextual Expansion

Including related fields or tasks
“Natural language processing” →
[“natural language processing”,
“text analysis”,
“computational linguistics”,
“language modeling”]

Temporal Expansion

Expanding for common abbreviations and alternative names →
[“COVID-19 vaccines”,
“COVID vaccines”,
“coronavirus immunization”,
“SARS-CoV-2 vaccine”]

Entity-Based Expansion

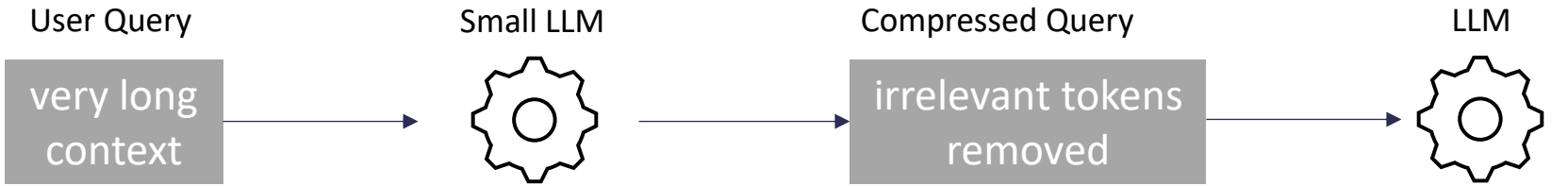
When query involves an entity, expanding with related people, products, or attributes associated with the entity can enhance retrieval quality.
“Tesla” →
[“Tesla”, “Elon Musk”,
“electrical vehicles”,
“autonomous driving”]

Retrieval-Augmented Generation:

RAG Improvements for Post-Retrieval

Retrieval-Augmented Generation

RAG Improvement for Post-Retrieval: Prompt Compression



- long context
- increased noise
- reduced LLM performance

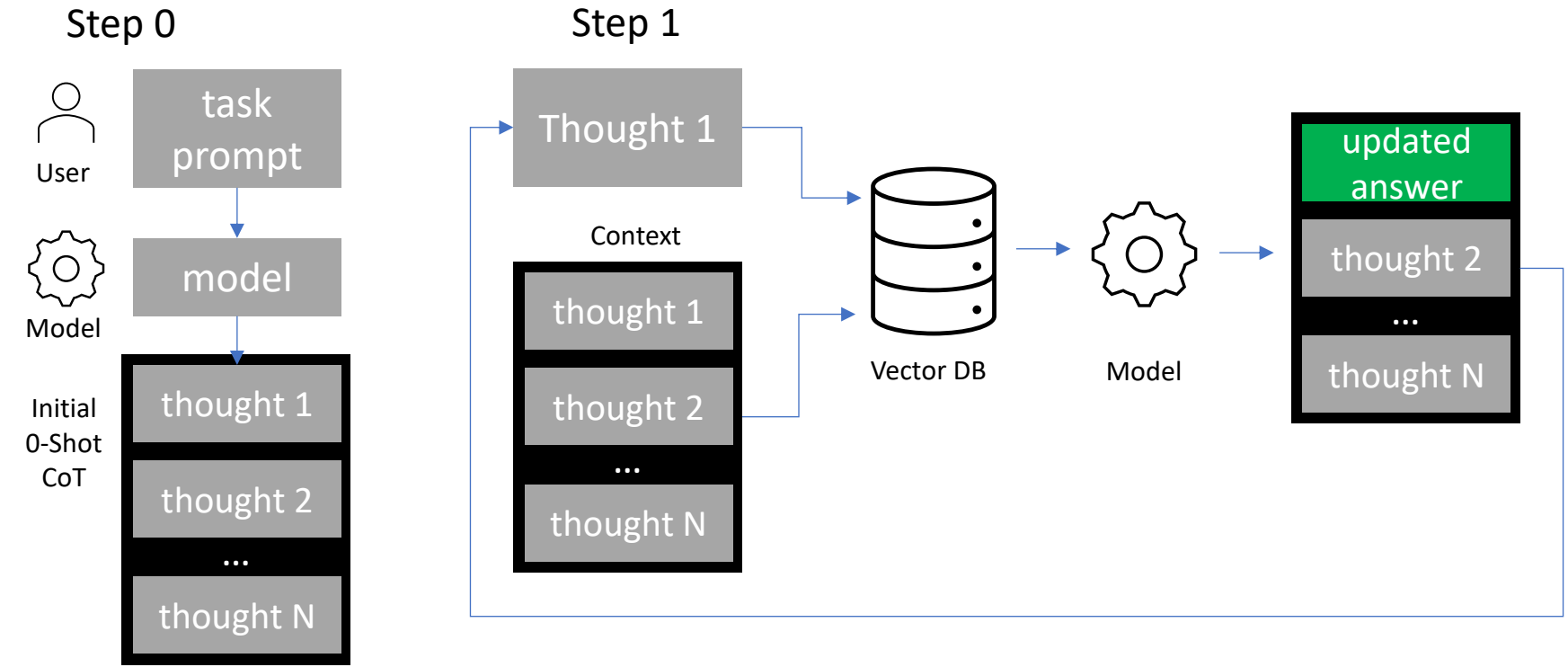
- cheap LLM

- irrelevant tokens removed

- powerful LLM
- cost ↓
- performance ↑
- efficiency ↑

Retrieval-Augmented Generation

Retrieval Augmented Thought



Source: Zihao Wang, et. al. „RAT: Retrieval Augmented Thoughts Elicit Context-Aware Reasoning in Long-Horizon Generation“

Retrieval-Augmented Generation:

RAG Alternatives

Retrieval-Augmented Generation

Prompt Caching