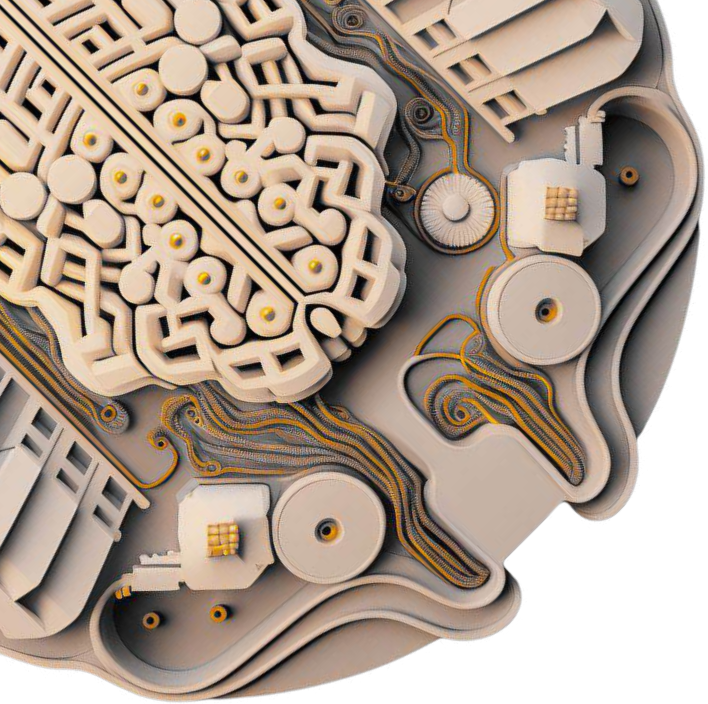

DATA INNOVATION SUMMIT 2024 MEA

EQT

MOTHERBRAIN

Knowledge Graph in Private Equity: LLM-enhanced Construction, Contextual Retrieval, and Reasoning

Lele Cao

Ph.D., Principal AI Research Scientist

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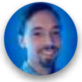
Credits also to:



Mark Granroth-Wilding

Valentin Buchner

Vilhelm von Ehrenheim

Drew McCornack

EQT & Motherbrain

- EQT: Private Equity Fund
  - Global investment fund w €200Bn+ AUM
  - Buys, grows & sells companies
  - Venture Capital, Buyout, Infrastructure, etc.

- Motherbrain: Data & Machine Learning Platform
  - Support investment professionals globally
  - Merging and enriching data using AI (on GCP)

- Read more about us → https://motherbrain.ai

Agenda

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Approach

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Contextual Retrieval

Reasoning

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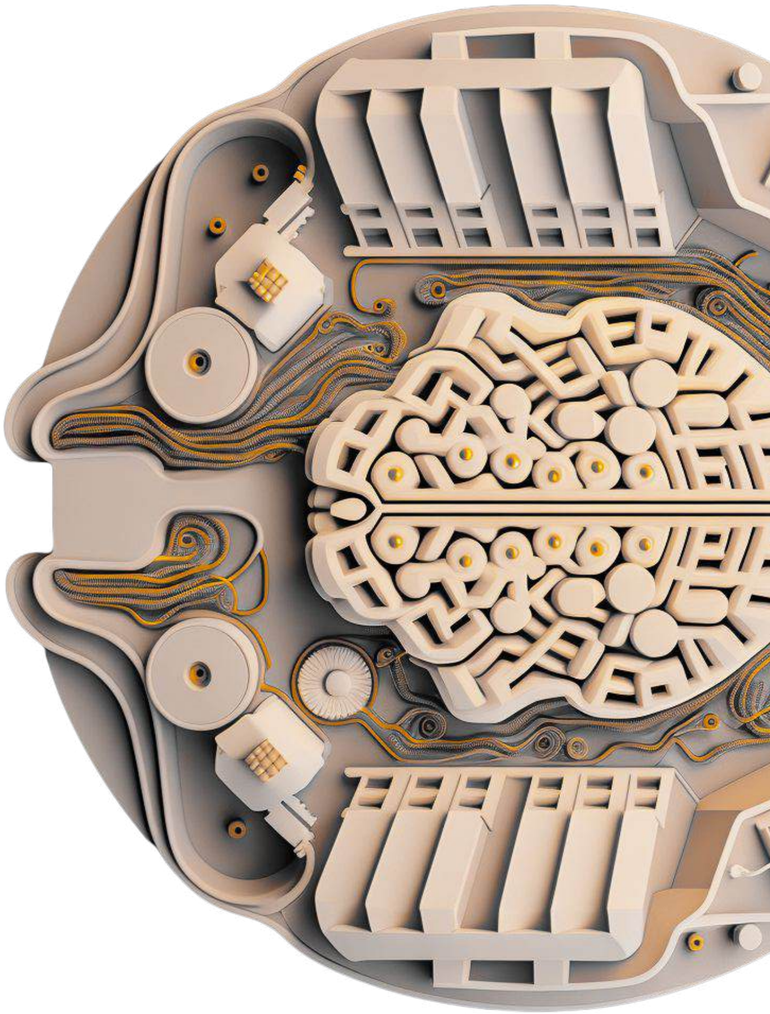


Motivation: a simplified view of deal process

Sourcing

- Which companies exists within my mandate?
- How do I make sure to spend time on interesting opportunities?
- What does the market look like around a deal?

Due Diligence

- What are the risks and attractions in this opportunity?
- What is the full potential this company can achieve?
- Who do we know we can ask for insights?

Holding

- How can we make sure to fulfil the full potential plan?
- What are the potential disruptions and market trends?
- How are we actually tracking on the plan?

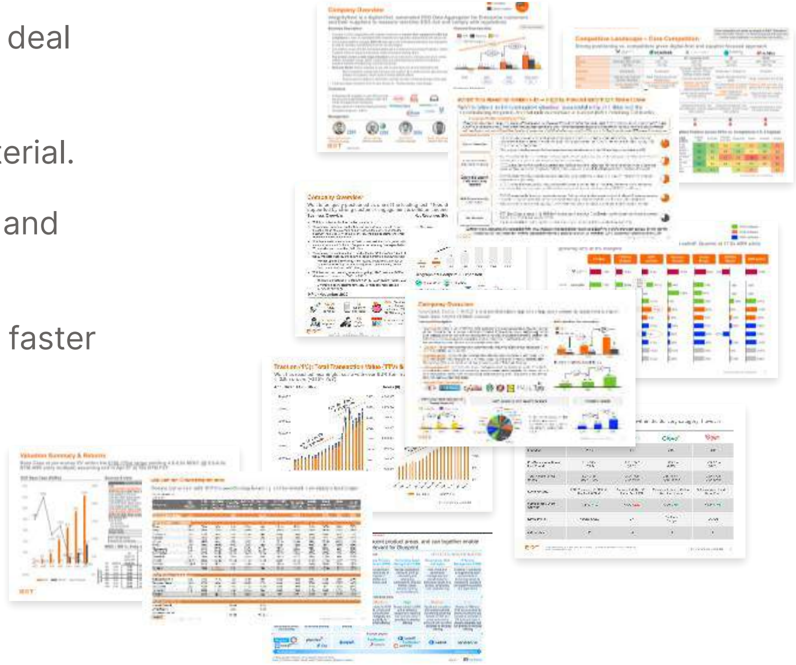
Exit

- How do we position the deal up for a successful sale?
- How can we make sure the company is in good health and can continue to grow?
- Which bankers and advisors should I talk to?

Motivation: leverage proprietary knowledge

Proprietary Knowledge

- So much interesting information is gathered throughout a deal process.
- EQT has been doing this since 1994… there is a lot of material.
- Reading through material is pretty intense as most decks and market reports are very dense. And long…
- But understanding historical deals is very important to be faster and smarter in future deal assessments.



Motivation: leverage third-party knowledge

Third-party Knowledge

- External experts and consultants often provide valuable insights that are not available internally.
- Leverage industry specialists can bring in-depth market analyses and fresh perspectives.
- Third-party data sources can offer objective viewpoints, free from internal biases.
- Most subscription-based sources are structured, hence easier to integrate.

PitchBook crunchbase ... ...

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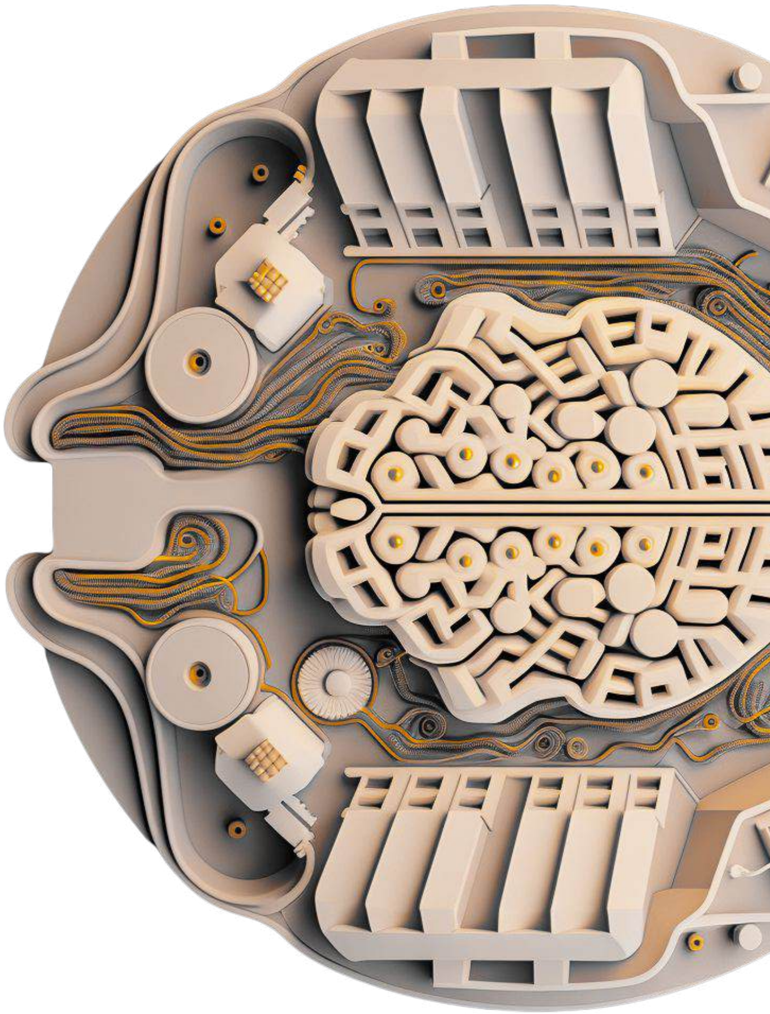

Approach: objective and applications

Develop an Intelligent and Knowledgeable Agent/Service to help deal professionals in many applications:

Ask a question about

- Mergers & Acquisitions
- Competitor Analysis
- Market Mapping
- Due Diligence Support
- Portfolio Company Growth Strategy
- Investment Thesis Formulation
- ... ...

→

→

Answer
here are some suggestions for deal advisers ... ...

Approach: a concrete example

Develop an Intelligent and Knowledgeable Agent/Service to help deal professionals in many applications:

Ask a question
We are looking at a deal of a company named ManyPets (manypets.com). Can you suggest some deal experts in related sectors and also some direct competitors in EU?

→

→

Answer
here are some suggestions for deal advisers in the pet insurance sector, as well as some direct competitors in the EU:
...

Approach: LLM prompting

Ask a question
We are looking at a deal of a company named ManyPets (manypets.com). Can you suggest some deal experts in related sectors and also some direct competitors in EU?

LLMs
ChatGPT
LLaMA
Gemini
Mistral
Claude
...

Answer
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...

Answer
here are some suggestions for deal advisers in the pet insurance sector, as well as some direct competitors in the EU:
...

Problem: Lack domain-specific and up-to-date knowledge.

Approach: RAG - retrieval augmented generation

Ask a question
We are looking at a deal of a company named ManyPets (manypets.com). Can you suggest some deal experts in related sectors and also some direct competitors in EU?

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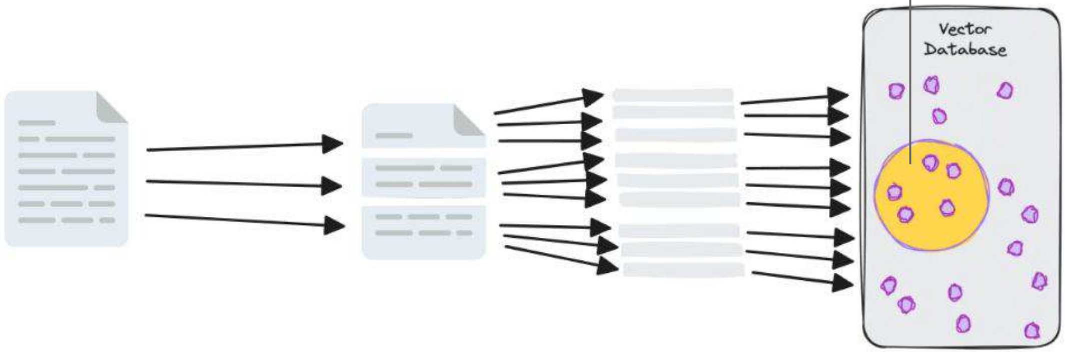
Retrieve document slices



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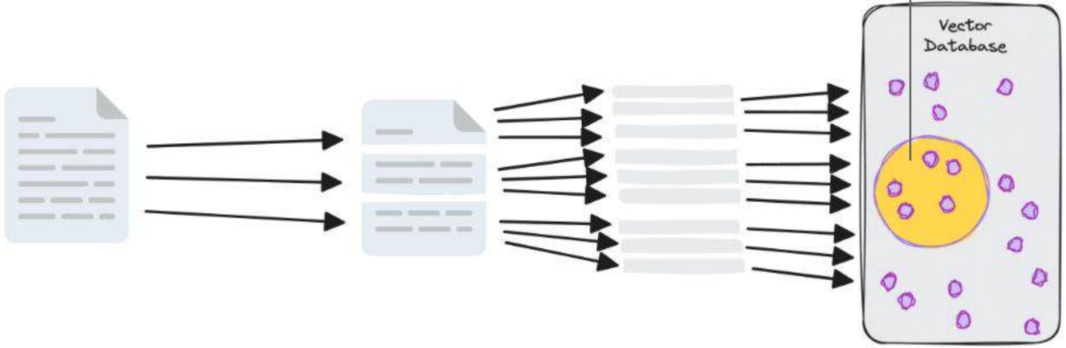

Problem:
- not modeling for PE-specific entities and their relationships;
- hard to integrate the third-party knowledge.

Approach: RAG over KG (knowledge graph)

Ask a question
We are looking at a deal of a company named ManyPets (manypets.com). Can you suggest some deal experts in related sectors and also some direct competitors in EU?

LLMs
ChatGPT
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Gemini
Mistral
Claude
...

Reasoning

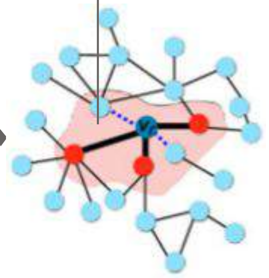
Answer
here are some suggestions for deal advisers in the pet insurance sector, as well as some direct competitors in the EU:
...

Retrieve relevant sub-graph

Third-Party Knowledge (Structured Data)

Construct

Proprietary Knowledge (Unstructured Docs)



Knowledge Graph

Approach: RAG over KG (knowledge graph)

Three Key Components:

1. **KG Construction** - Extract relevant entities, relations, and attributes from **proprietary documents** and **third-party data**.
2. **Contextual Retrieval** - According to the context provided by the query/question, retrieve the relevant sub-KG for LLM to reason about.
3. **Reasoning** - With the query/question and the retrieved sub-KG, generate the response/answer.

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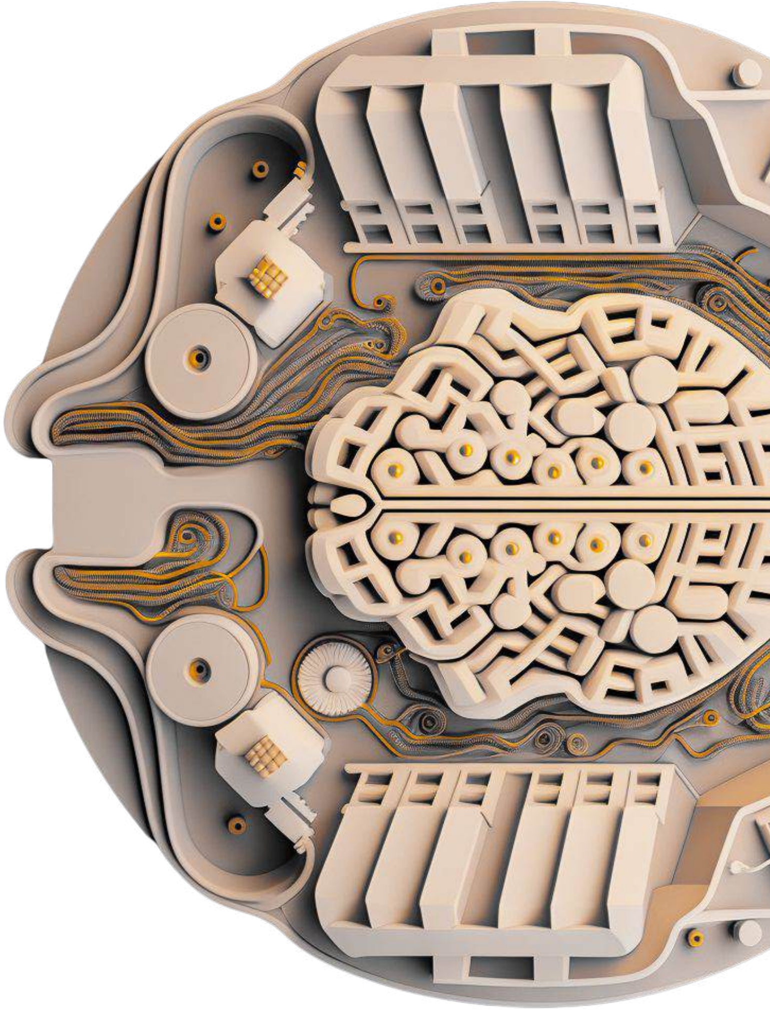
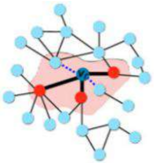
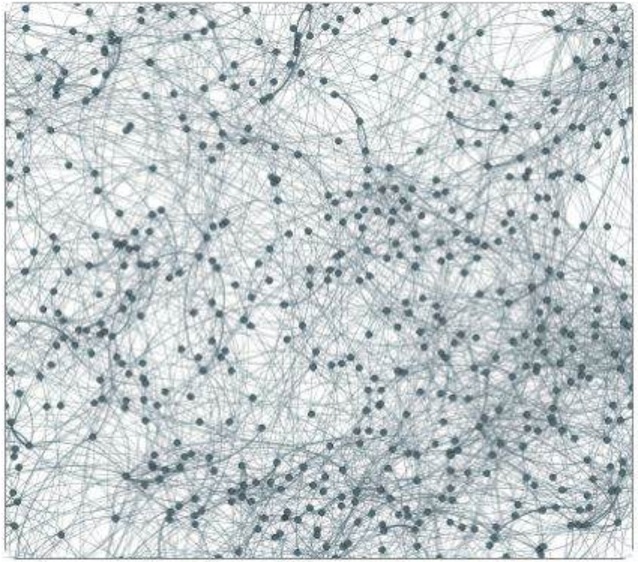


Third-Party Knowledge (Structured Data) $\xrightarrow{\text{Construct}}$



KG Construction: CompanyKG

- **Purpose**: quantify similarities among companies.
- **Example use cases**:
    - Market mapping
    - Competitor analysis
    - Mergers and Acquisitions (M&A)
- **Data source**: mostly third-party structure data, such as Pitchbook, Crunchbase, etc.

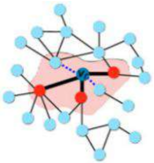


A fraction of the entire graph

https://github.com/EQTPartners/CompanyKG

Third-Party Knowledge (Structured Data)

Construct

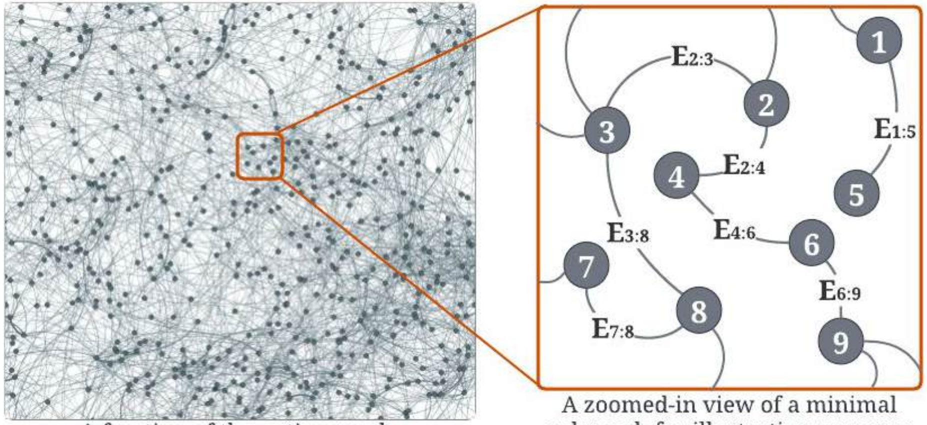


KG Construction: CompanyKG

Relations: 15 relation types in 6 categories

- competitive landscape
- industry sector
- M&A transactions
- people's affiliation
- news/event engagement
- and product positioning

51.06 million weighted edges



A fraction of the entire graph

A zoomed-in view of a minimal subgraph for illustrative purposes

Edge weights: 15-dim vector, where the *i*-th dimension is the weight of the *i*-th edge type (ET*i*)

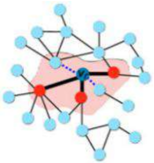
$E_{1:5}$ [0.0, 1.0, 0.0, 2.0, ... 5.1, 0.0, 1.6] $\in \mathbb{R}^{15}$

$E_{2:3}$ [0.0, 1.0, 1.0, 0.0, ... 0.0, 0.0, 2.3] $\in \mathbb{R}^{15}$

⋮

Third-Party Knowledge (Structured Data)

Construct

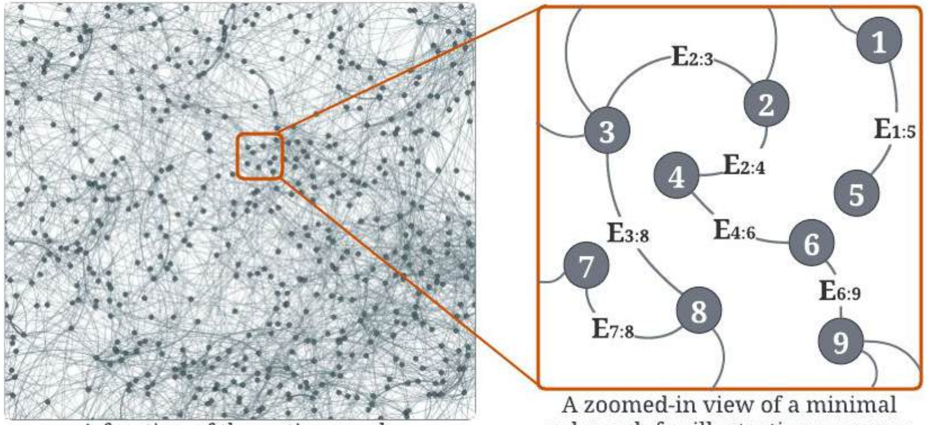


KG Construction: CompanyKG

Nodes: 1.17 million companies

Node feature: description/keywords embeddings:

- multilingual BERT
- ADA2 (GPT3.5)
- SimCSE
  https://doi.org/10.18653/v1/2021.emnlp-main.552
- PAUSE
  https://doi.org/10.18653/v1/2021.emnlp-main.791



A fraction of the entire graph

A zoomed-in view of a minimal subgraph for illustrative purposes

Node features: company description embeddings from 4 language models

1
mSBERT: $[0.32, 0.01, \ldots -0.49] \in \mathbb{R}^{512}$
ADA2: $[0.05, 0.20, \ldots\ 0.35] \in \mathbb{R}^{1536}$
SimCSE: $[0.29, 0.16, \ldots -0.24] \in \mathbb{R}^{768}$
PAUSE: $[0.02, 0.73, \ldots\ 0.88] \in \mathbb{R}^{32}$

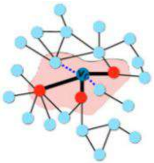
2
mSBERT: $[0.90, 0.53, \ldots\ 0.05] \in \mathbb{R}^{512}$
ADA2: $[0.44, -0.10, \ldots\ 0.35] \in \mathbb{R}^{1536}$
SimCSE: $[0.83, 0.01, \ldots\ 0.54] \in \mathbb{R}^{768}$
PAUSE: $[-0.22, 0.06, \ldots\ 0.90] \in \mathbb{R}^{32}$

⋮

https://github.com/EQTPartners/CompanyKG

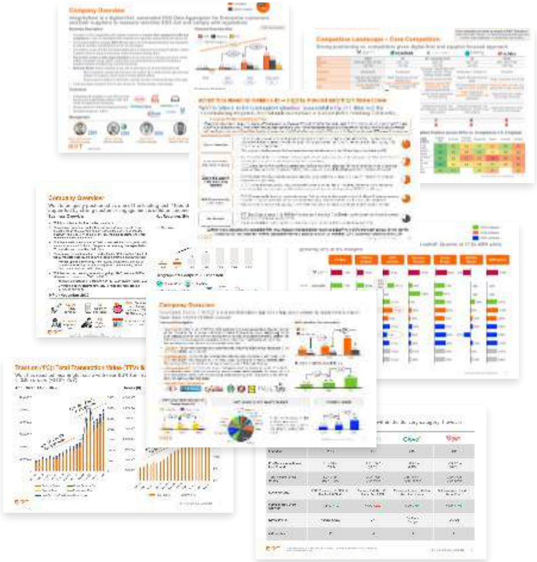
Proprietary Knowledge
(Unstructured Docs)

Construct



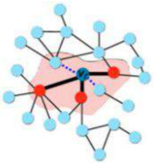
KG Construction: PEKG

- **Purpose**: Construct Knowledge Graph for EQT's PE deals.
- **Data source**: EQT's proprietary deal related documents. Each document is about a specific company (a.k.a., target company) in scope.



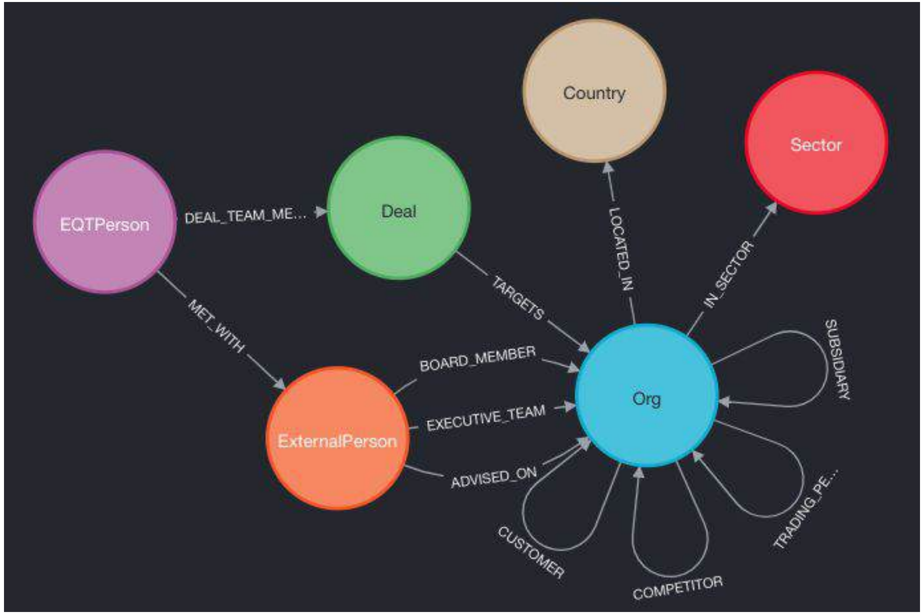
EQT's PE
deal docs

Proprietary Knowledge (Unstructured Docs) **Construct**

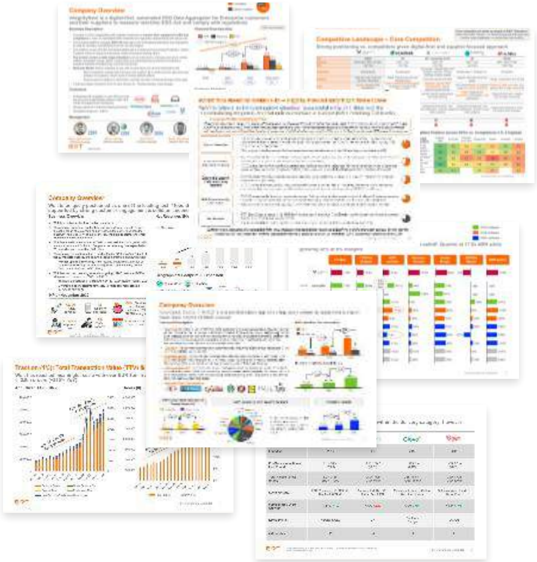


KG Construction: PEKG

- What **entities** and **relations** we extract and build into PEKG?



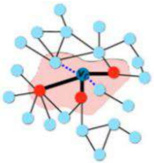
Extraction Guide (Meta Graph)



EQT's PE deal docs

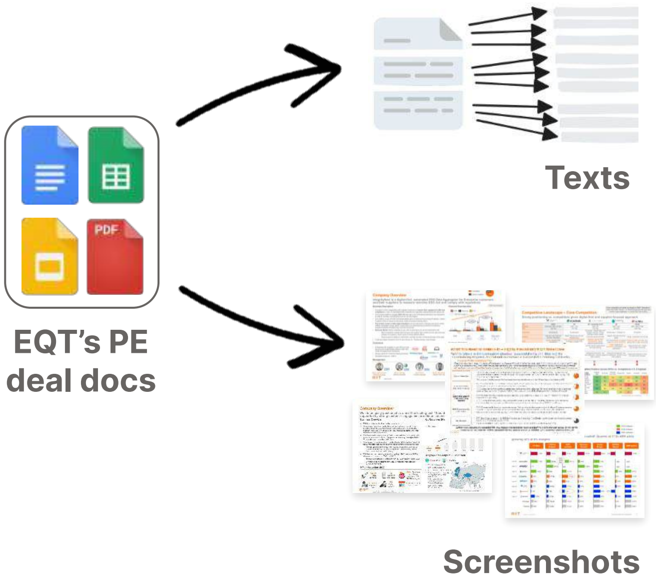
Proprietary Knowledge
(Unstructured Docs)

Construct



KG Construction: PEKG

- How do we automate PEKG construction?



Proprietary Knowledge
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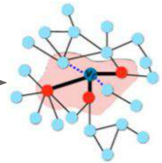

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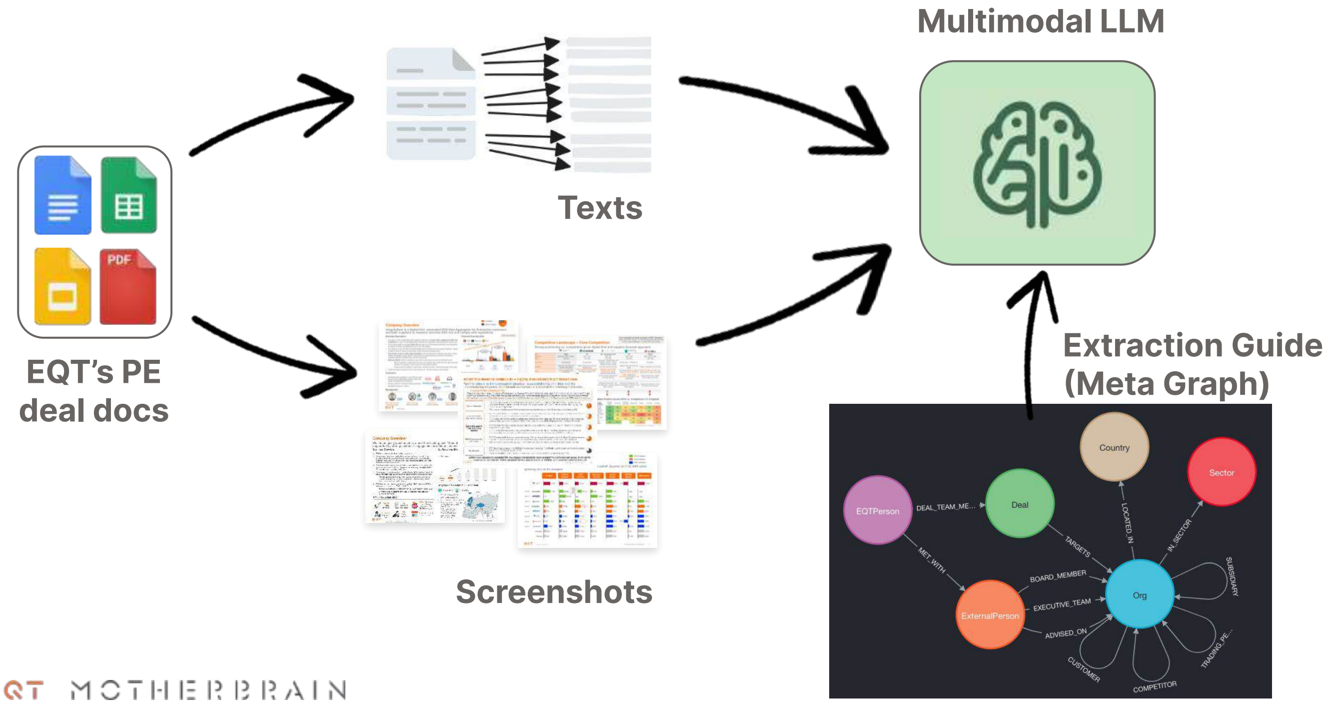

Proprietary Knowledge
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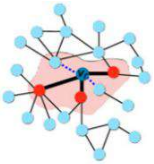

KG Construction: PEKG

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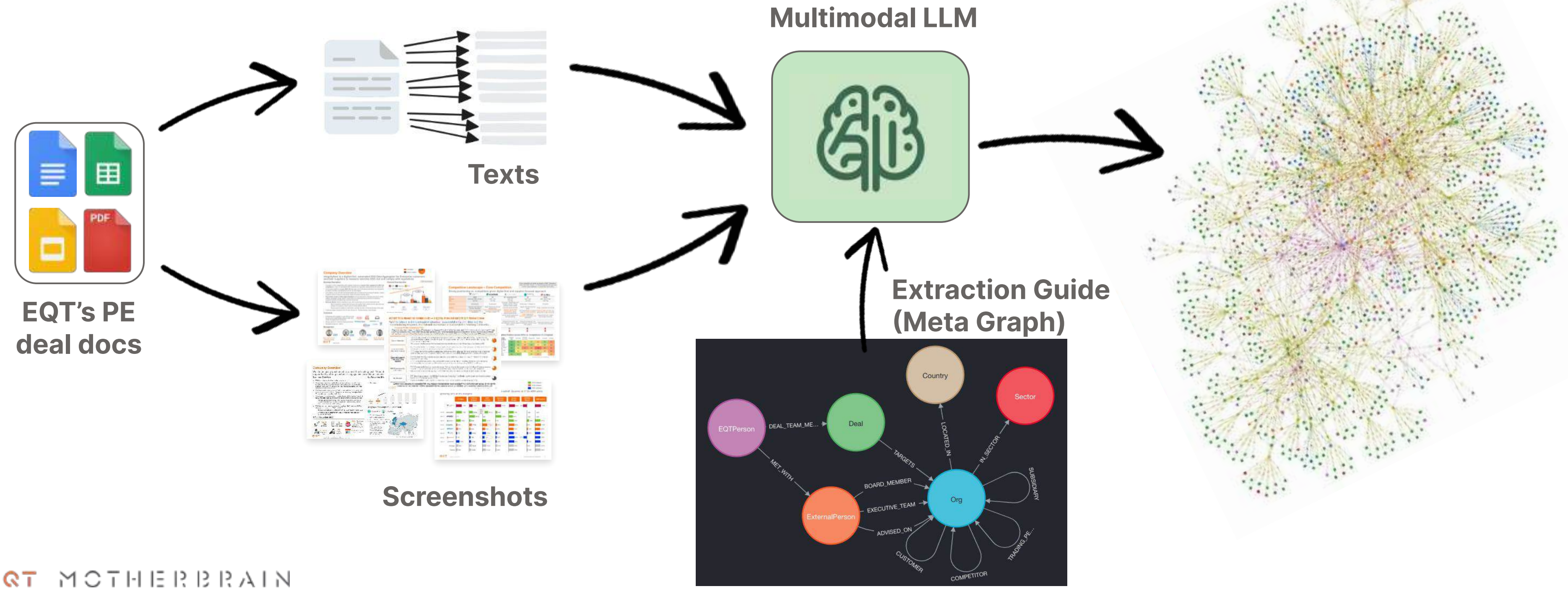
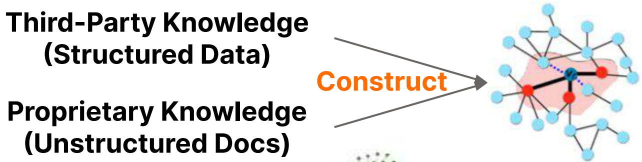
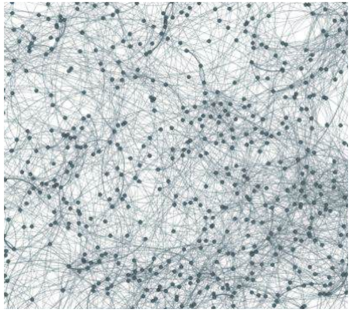
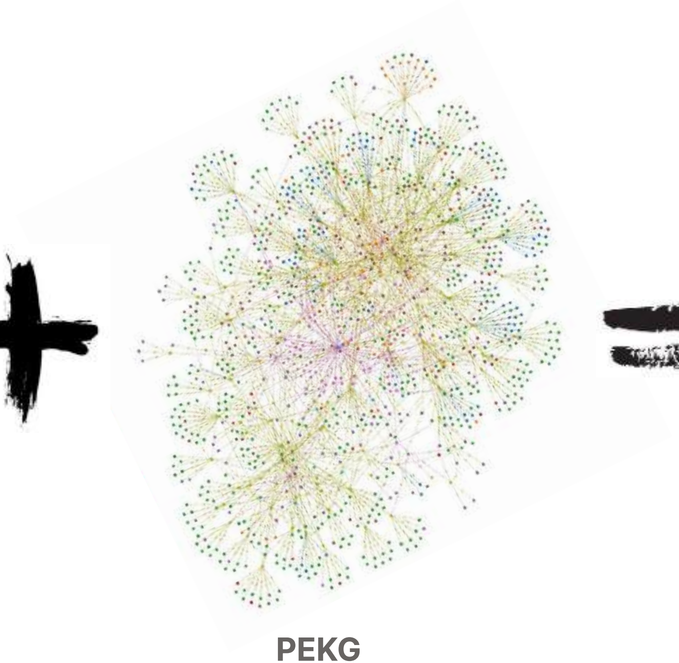


KG Construction: PEKG + CompanyKG

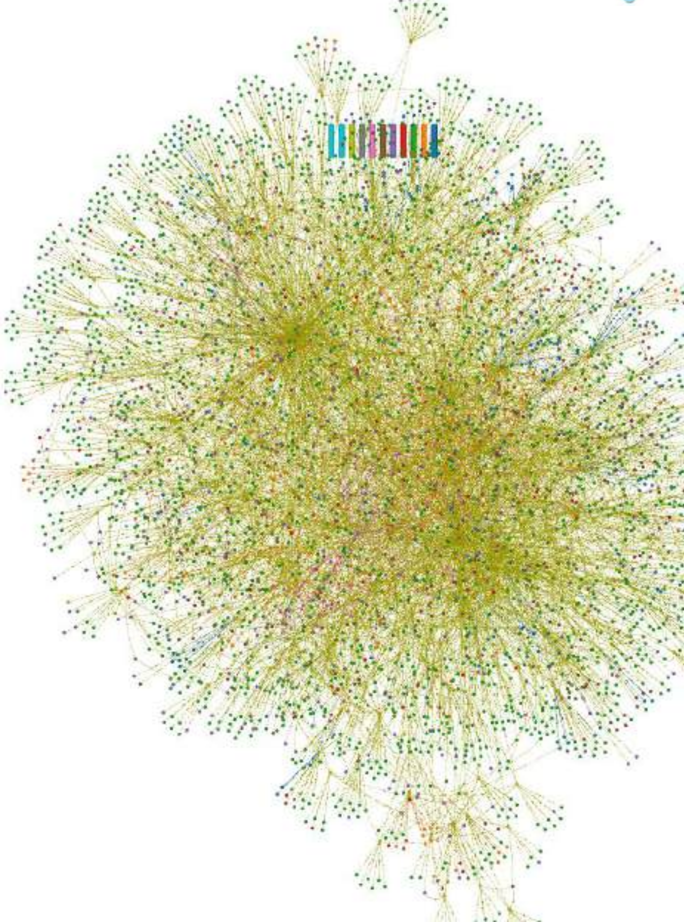




CompanyKG



PEKG



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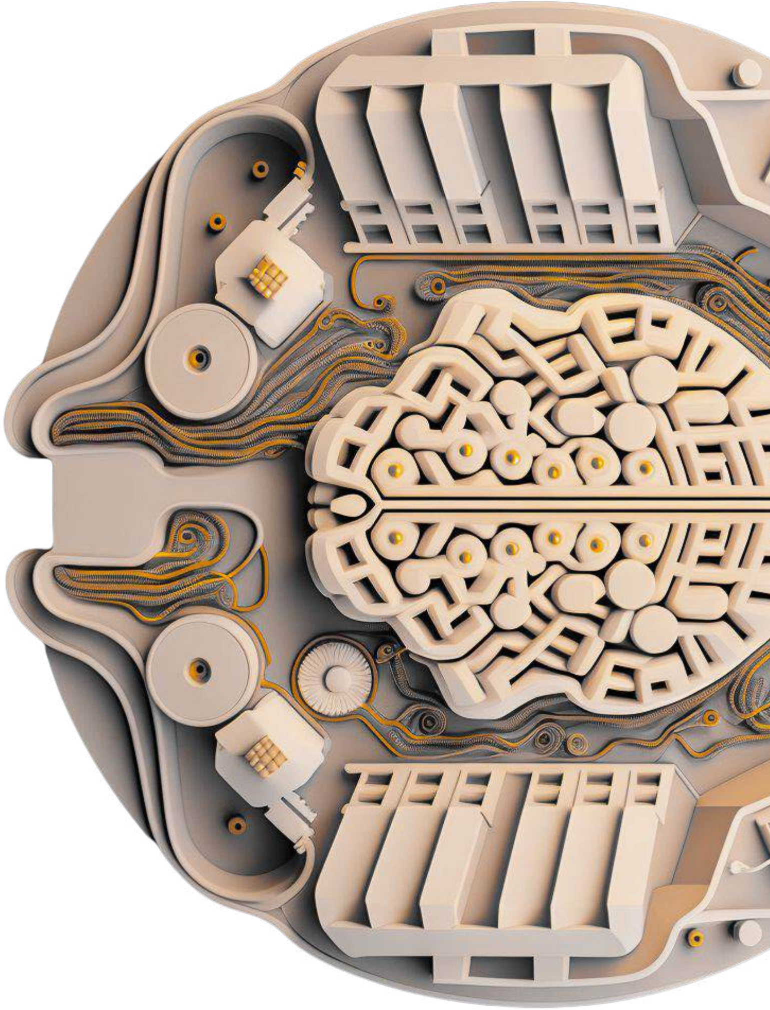
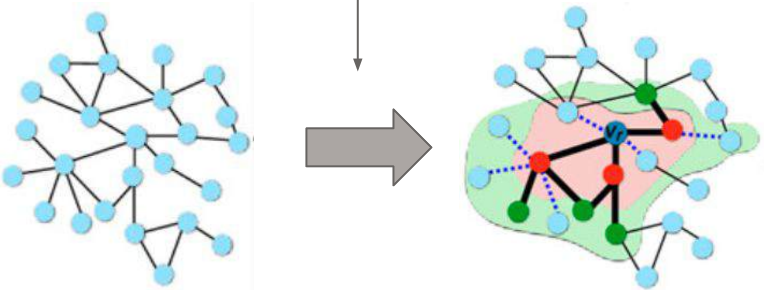


Contextual Retrieval

Objective: retrieve a sub-KG from the entire KG according to the context of the input query/question.

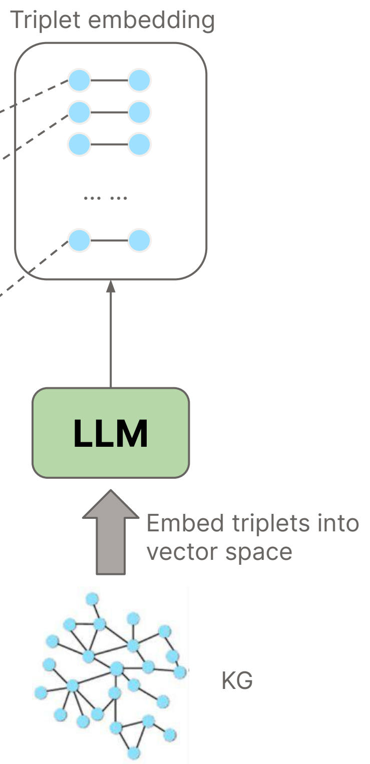
- The existing work mostly
  - assumes the availability of a contextual sub-KG, which is not true in reality;
  - or adopt a overly simplified approach, such as randomly expand 2 steps from a center node.



Contextual Retrieval: Semantic Triplets Search

Examples of “Triplet”s:

Start node	Relation	End node
EQT	— is based in	Stockholm
Martin	— worked with	Mark
…	…	…
KTH	— belongs to	University



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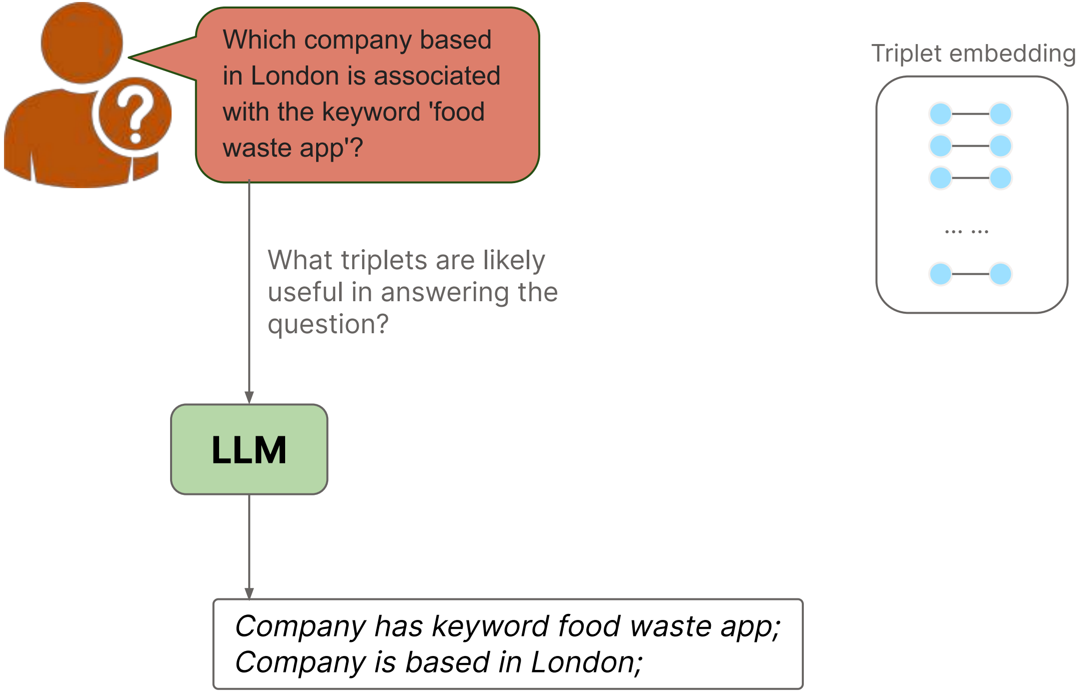

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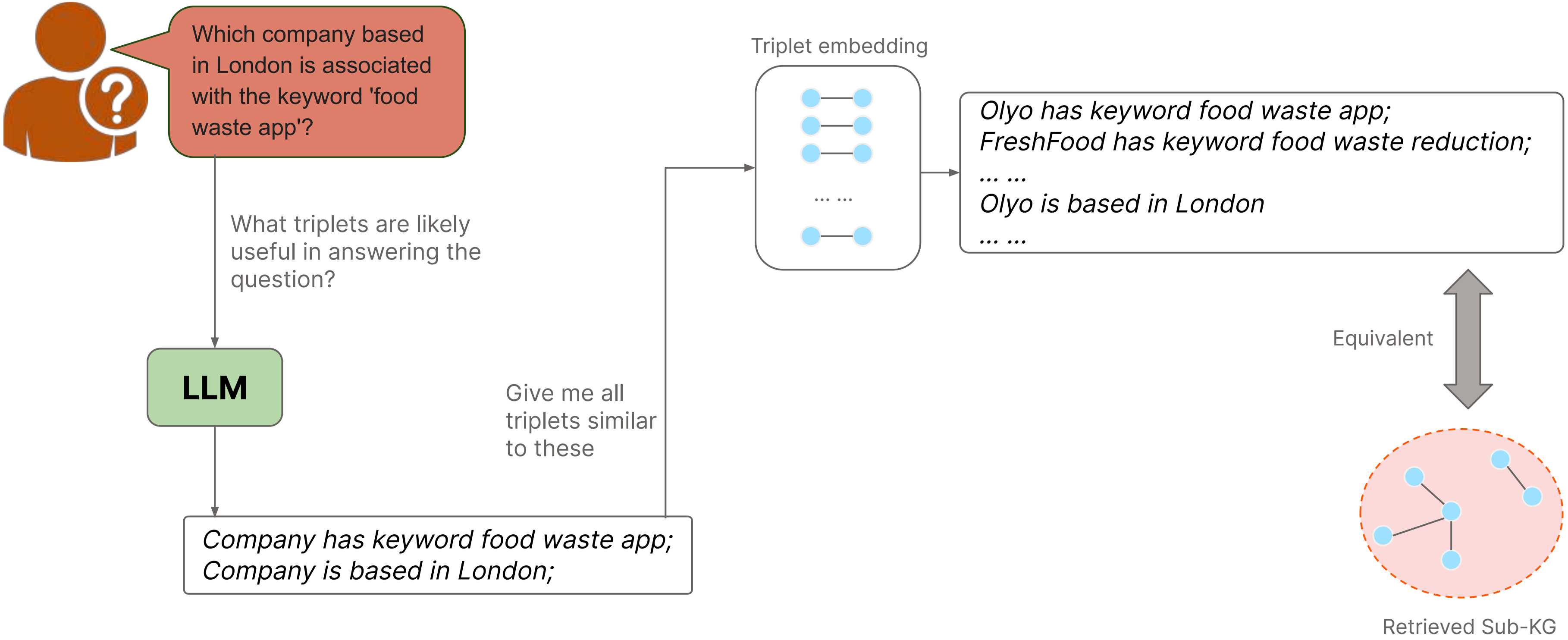

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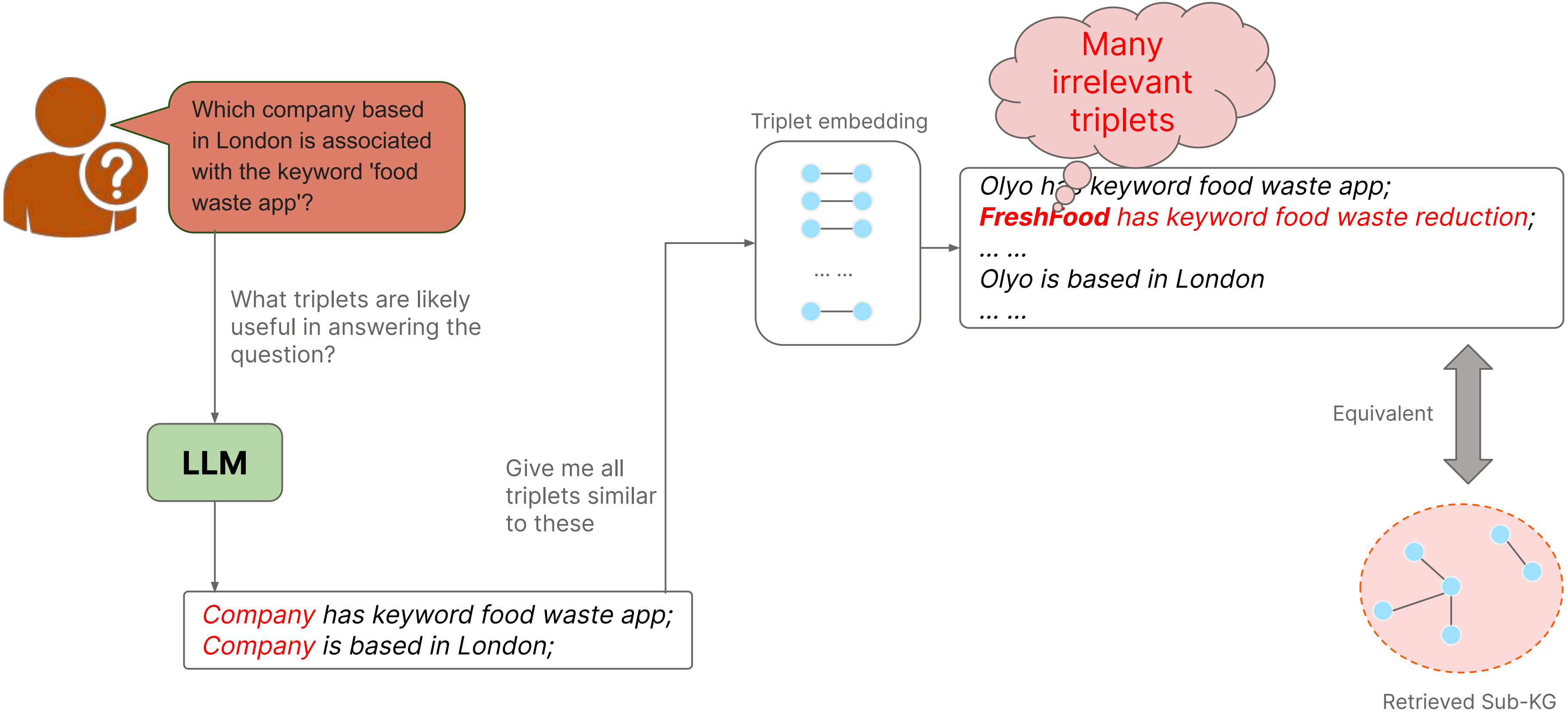
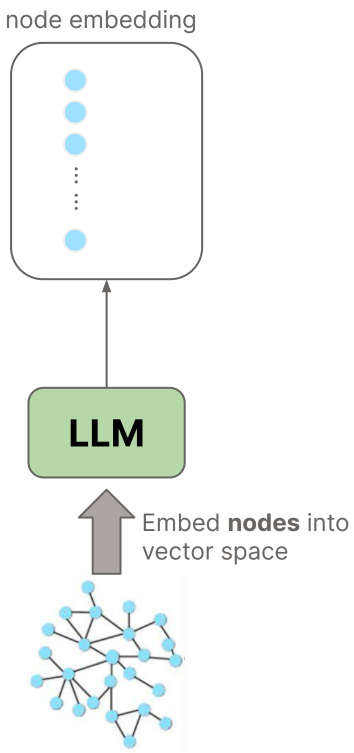


Contextual Retrieval: NER + Cypher



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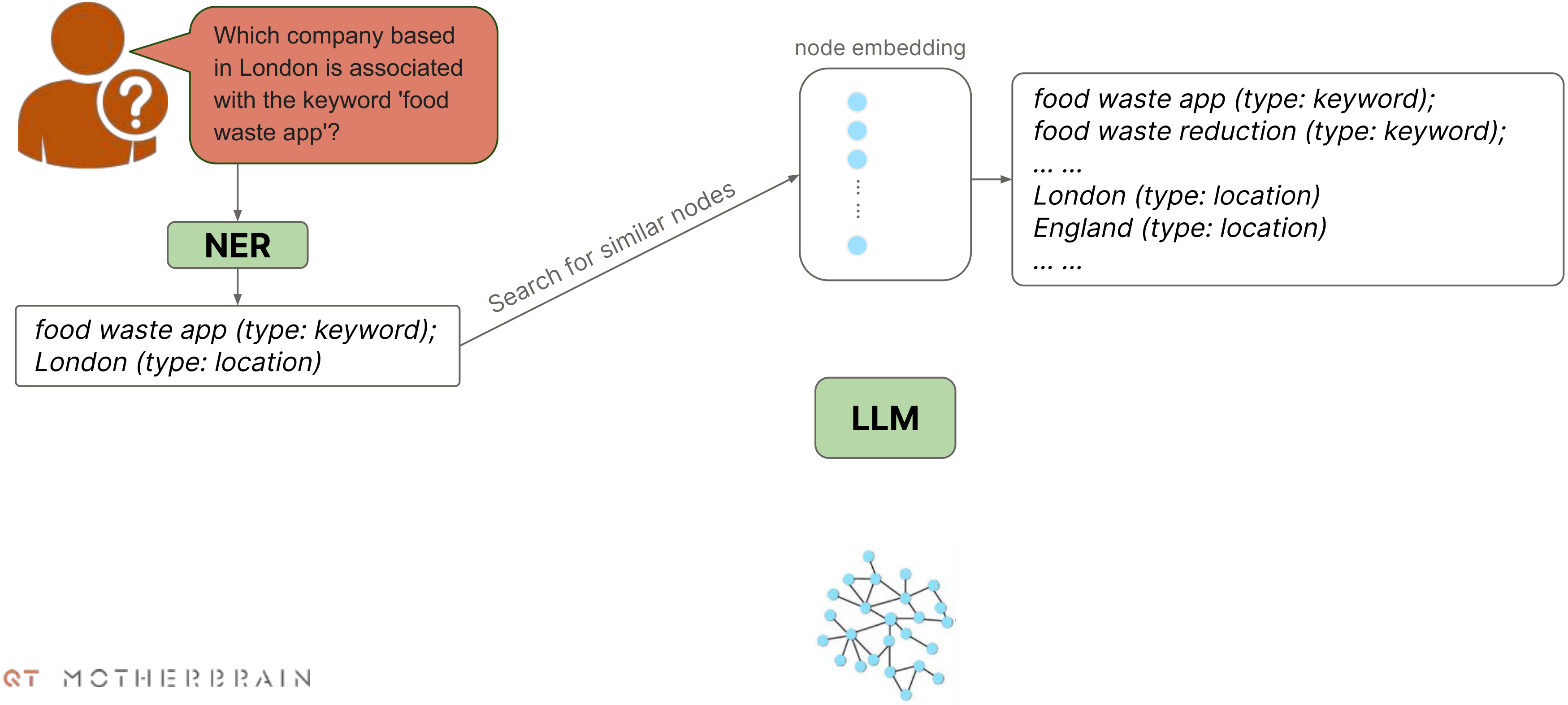

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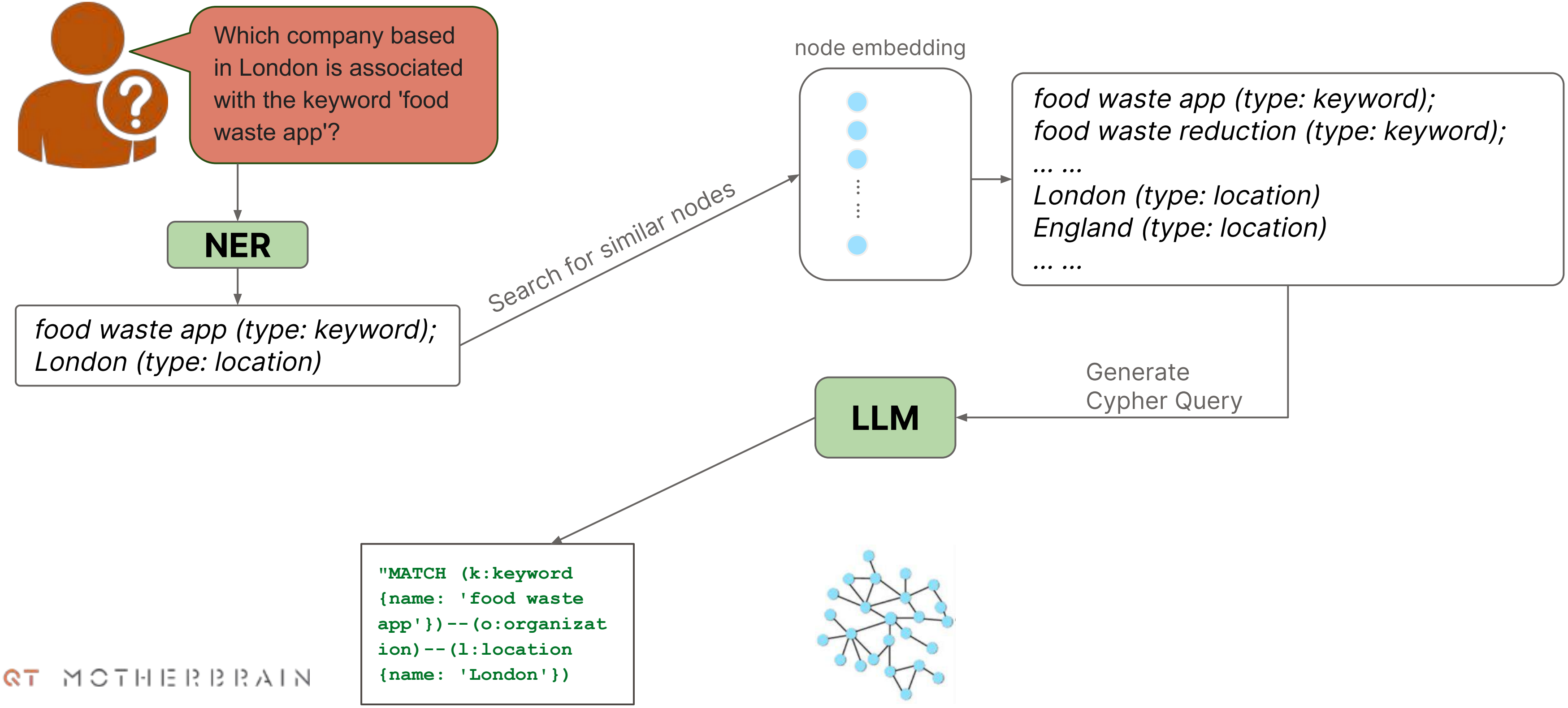

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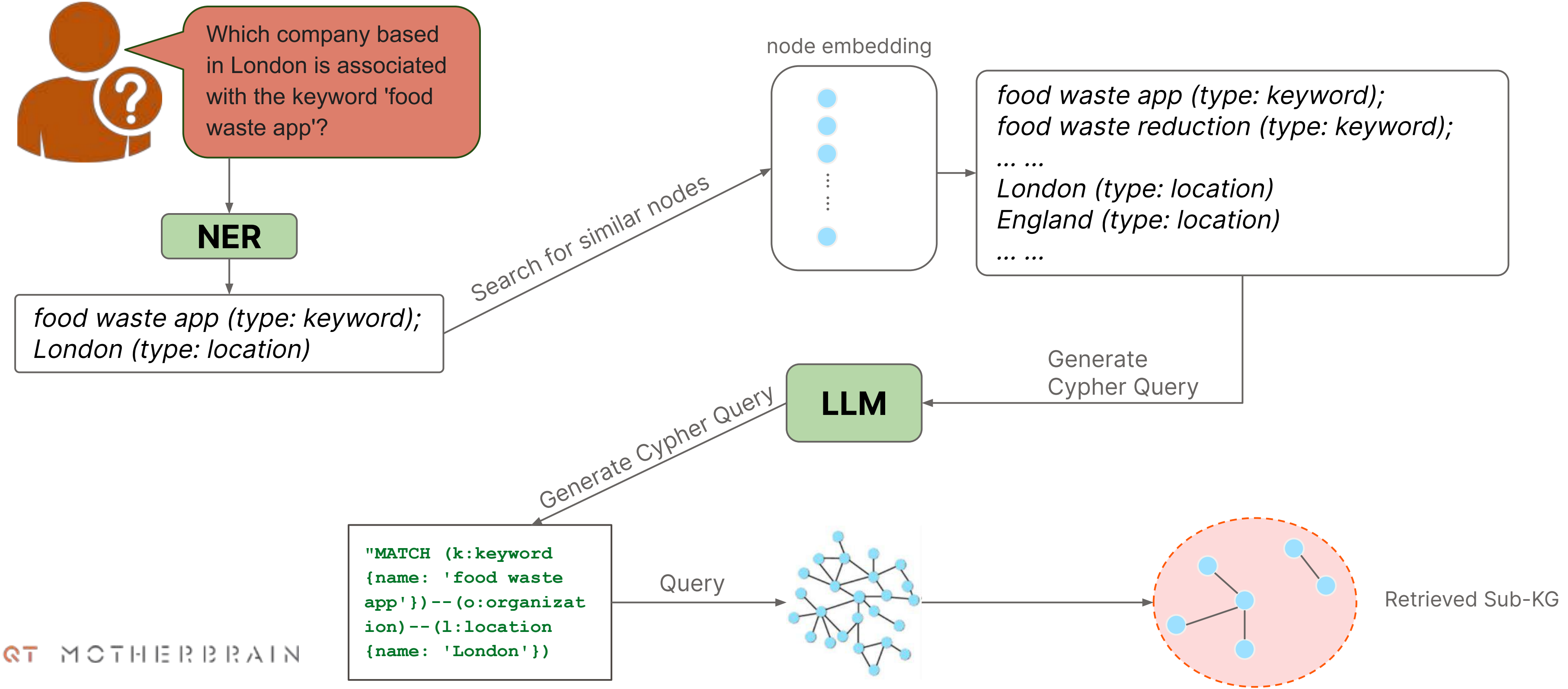

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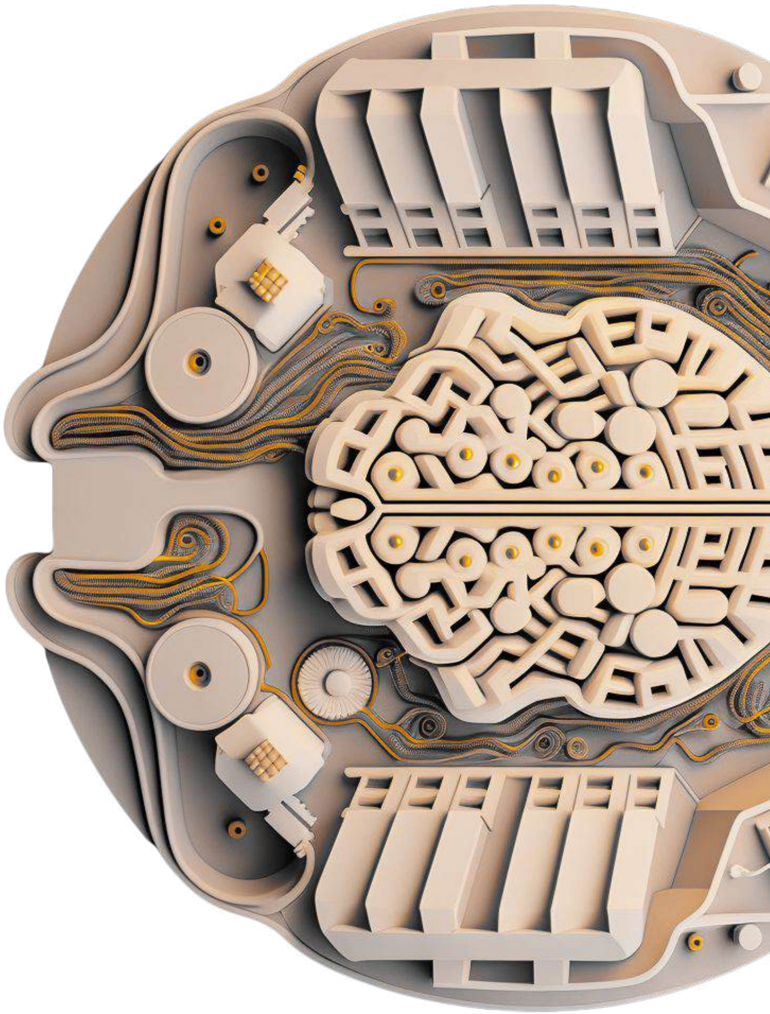
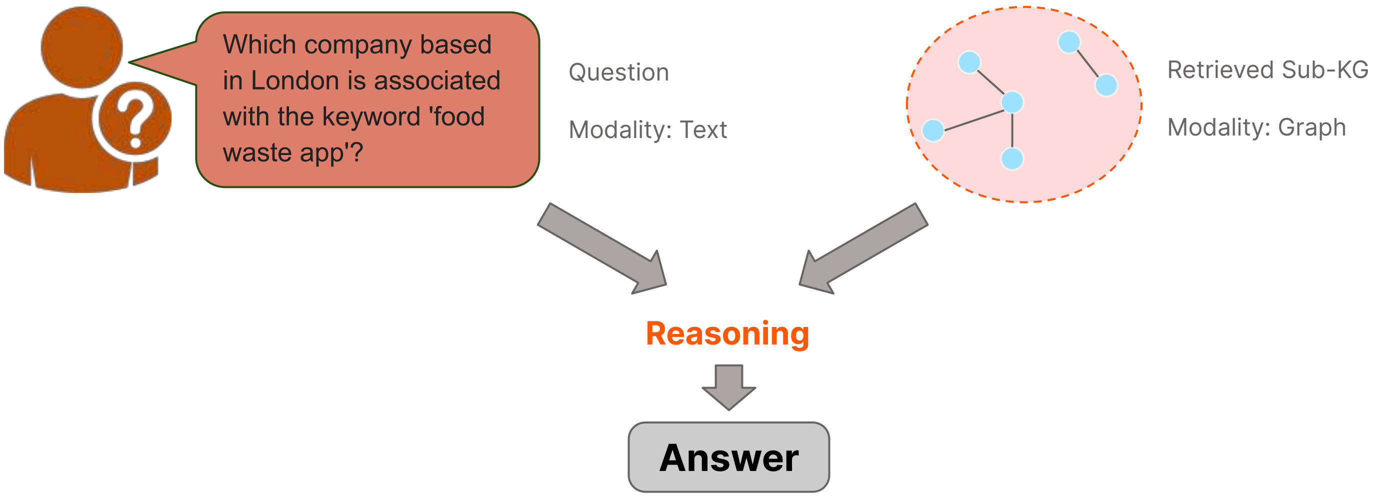


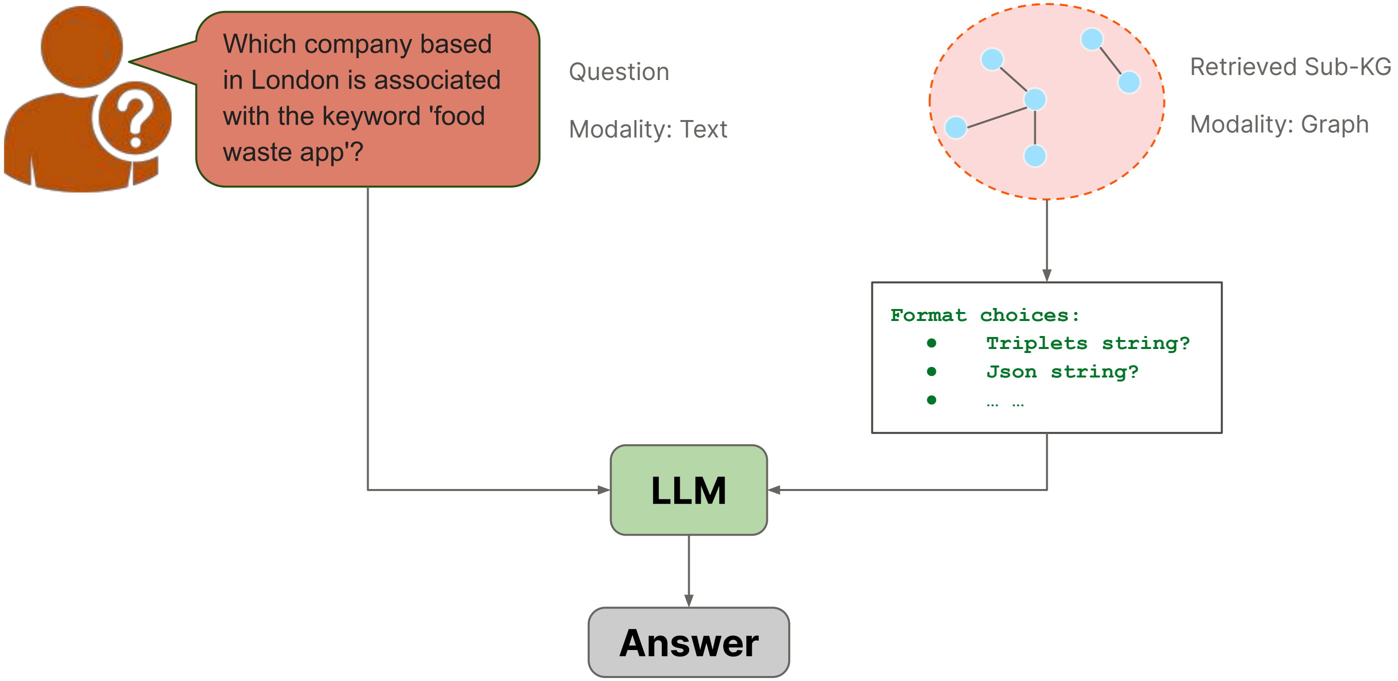
Reasoning

Objective: generate answer to the textual question using the retrieved sub-KG as input context.



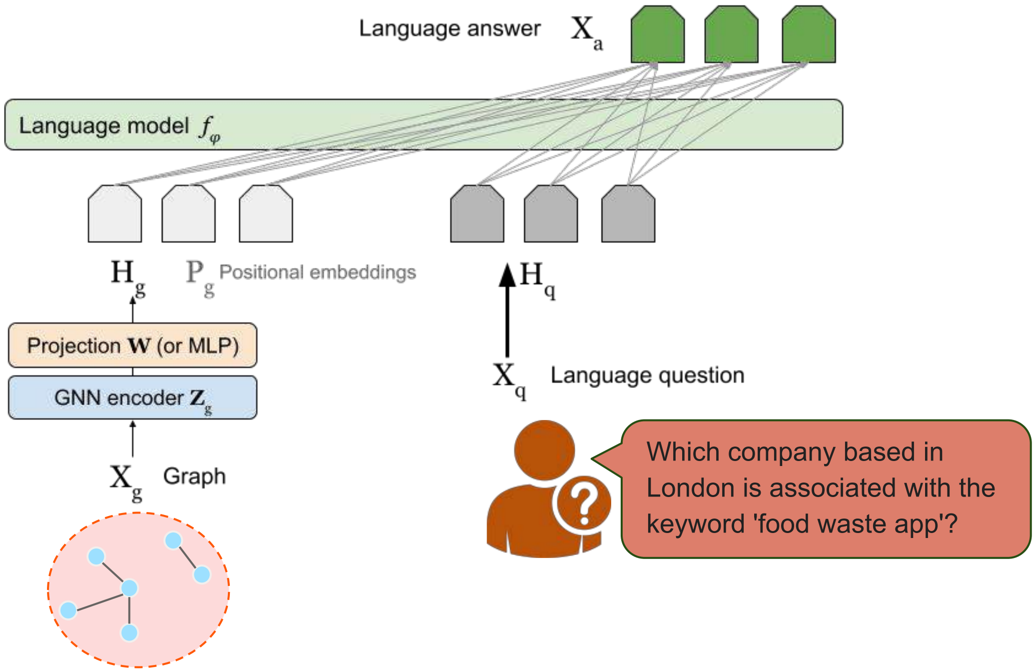
Reasoning: Zero-shot (simple option)

Zero-shot: transform the sub-KG into texts.



Reasoning: Cross-modal finetune (cool option)

Cross-modal finetune: jointly tune the word (text) and node (graph) into the same token space.



For more details, see this paper: https://arxiv.org/pdf/2402.07197

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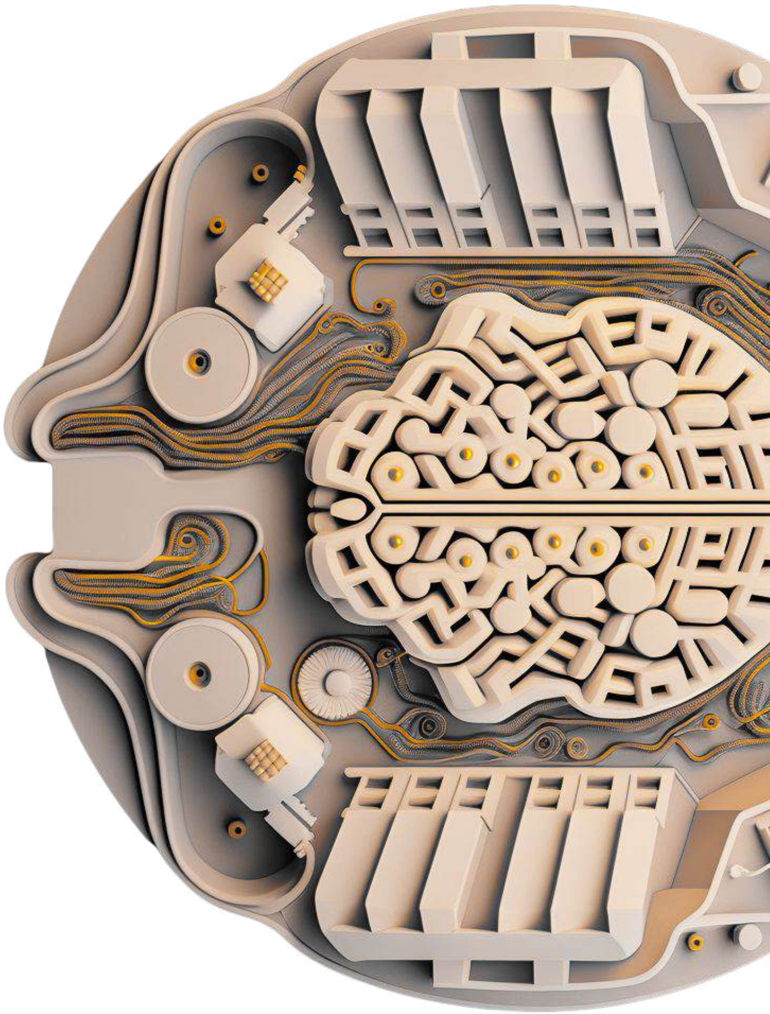

Summary

Knowledge Graph can empower LLM to facilitate PE investment activities.

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ChatGPT
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Gemini
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Reasoning

Answer
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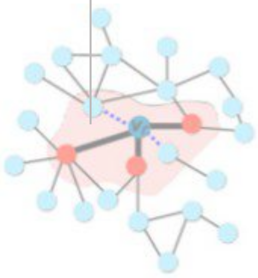
Retrieve relevant sub-graph

Third-Party Knowledge (Structured Data)

Construct

Proprietary Knowledge (Unstructured Docs)



Knowledge Graph

Summary

Knowledge Graph can empower LLM to facilitate PE investment activities.

Reasoning

Retrieve

- Define the entities and relation first.
- Combine proprietary and 3rd-party data.
- Multimodal LLM enables automatic KG extraction.

Construct

Summary

Knowledge Graph can empower LLM to facilitate PE investment activities.

Reasoning

Retrieve

- Identify named entities in question first.
- Graph database works better than vector database.
- Ask LLM to generate retrieval query.

Construct

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- Combine proprietary and 3rd-party data.
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Summary

Knowledge Graph can empower LLM to facilitate PE investment activities.

Reasoning

- Zero-shot is simple and performs OK!
- Cross-modal finetune is new and cool, yet will be challenging to do well.

Construct

- Define the entities and relation first.
- Combine proprietary and 3rd-party data.
- Multimodal LLM enables automatic KG extraction.

Retrieve

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- Graph database works better than vector database.
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Thanks!

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