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Scalable Conversational Capabilities with Gen AI **MathCo** (TheMathCompany Inc.)

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Agenda

- Introduction
- Framework for GenAI use cases
- Fundamentals needed to develop a Conversational Capability
- Approach from basic to advanced Conversational capability
- Real World applications for Pharma

Introductions



Srivatsa Kanchibotla

- **Chief Data Science Officer @ MathCo**
- Started GenAI incubation/R&D hub in 2018
- Currently leading the **AI practice @ MathCo**
- Focus industries include **Pharma, Retail and CPG**



Ashwin Gopalakrishnan

- **Partner, Customer Success @ MathCo**
- Currently leading the **Pharma practice @ MathCo**
- Focused on developing custom data and analytics products for Pharma

Framework for GenAI use cases

Accessibility

Help process, discover and query

Recommendations

Provide suggestions based on multiple inputs

Execution

Work with systems to automate and execute

Planning

Create plans and intervene when necessary

Strategy

- Goals
- Initiatives
- Priorities

Value

- Workflows
- Decisions
- Solutions

Intelligence

- Models/Analyses
- KPIs
- Features

Foundation

- Operational data
- Raw data
- Infra & Tools

Capabilities

- Complexity of tasks increases through the continuum
- Feedback loops across layers become critical to perform more sophisticated tasks
- Left to right from Task Orientation to Goal Orientation

Layers

- Personas accessing each layer and their consequent expectations are different
- Continuum from bottom to top - Business Context Increases as you move up the layers
- Vertical integration ensures reuse across layers

How does this translate to technical needs?

Accessibility

Help process, discover and query

Recommendations

Provide suggestions based on multiple inputs

Execution

Work with systems to automate and execute

Planning

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- Operational data
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- IR + CE + Execution Env (EE)
- Multiple Sources + Agents – DBs + PPTs + PDFs
- Simple Decision Making – AI Makes simple closed domain constrained Decisions with Human in the Loop (HITL)
- **“Business Context” is Medium to high**

- Information Retrieval (IR) + Context Enrichment (CE)
- Single Source + Agent – DB or PPTs
- Accuracy and Costs
- **“Business Context” is low**

- IR + CE + EE + ReAct – AI in Autopilot
- External data sources – Eg: Pubmed
- Focus on Complex Decision Making and Reasoning – AI Makes multi hop multi step decisions in open domain with or without HITL
- **“Business Context” is very high**

Fundamental ingredients for a Conversational Capability



Data
Source

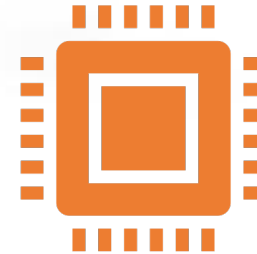


Context
Enrichment



LLMs

Focus for remainder
of the discussion



Platform
& Infra



User
Personas



Use Case: Extracting value from Primary Market Research

Context

- Primary market research is pivotal in developing strategic and tactical plans, marketing plans and driving growth
- Summarization of this rich information is manual
- Gen AI has unlocked discoverability of findings, ability to summarize info within documents and capability to synthesize complex insights from multiple sources

Business challenges

- Limited ability of LLMs to understand business terminology
- Inability to extract information from PDFs, PPTs
- Hallucinations
- Smaller context length that is provided with the user query

Solution Overview

Comprehensive framework that includes:

- Front-end application to enable conversations and prompting by business users
- Processing module to extract information from PPTs/PDFs
- Embedding and inferencing module – to retrieve most relevant answer

Retrieval Augmented Generation (RAG) is the secret sauce to ensure relevancy and accuracy of responses

Approach to scaling the “brain” behind Conversational Capability

Retrieval Augmented Generation

- Approach to improve relevancy and accuracy of responses from LLM
- Includes embedding component, vector storage and retrieval engine, search capabilities to find relevant answers



Foundational Models: Completions



Instruction Fine-tuned models



Basic RAG



Advanced RAG



Knowledge Graphs



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Foundational Model with completions has low accuracy of responses and higher chances of hallucinations, which can lower user confidence

What are the side effects of botox?

The side effects of botox are generally mild and temporary, and may include soreness, redness, swelling, or bruising at the injection site; headache; flu-like symptoms; and temporary drooping of the eyelids. Rarely, more serious side effects can occur, such as difficulty swallowing or breathing, muscle weakness, double vision, loss of bladder control, and an infection.

Note:

- Plain text is input by user
- Green highlighted text is output generated by LLM)

Outcomes:

- Accuracy of the responses is low.
- Chances for hallucinations are high



Instruction fine-tuned model helps make output much more human friendly

What are the side effects of botox? List out the top 5 as bullet points



- Headache: Botox injections can sometimes cause temporary headaches as a common side effect.
- Bruising: Some individuals may experience bruising at the injection site, which is usually temporary and fades within a few days.
- Drooping eyelids or eyebrows: In rare cases, Botox can cause temporary drooping of the eyelids or eyebrows, which typically resolves within a few weeks.
- Flu-like symptoms: Occasionally, individuals may experience flu-like symptoms such as fatigue, muscle weakness, or a general feeling of being unwell after receiving Botox injections.
- Allergic reactions: Although rare, some people may develop an allergic reaction to Botox, resulting in symptoms such as itching, rash, or difficulty breathing. Immediate medical attention should be sought if any severe allergic reactions occur.

Summary:

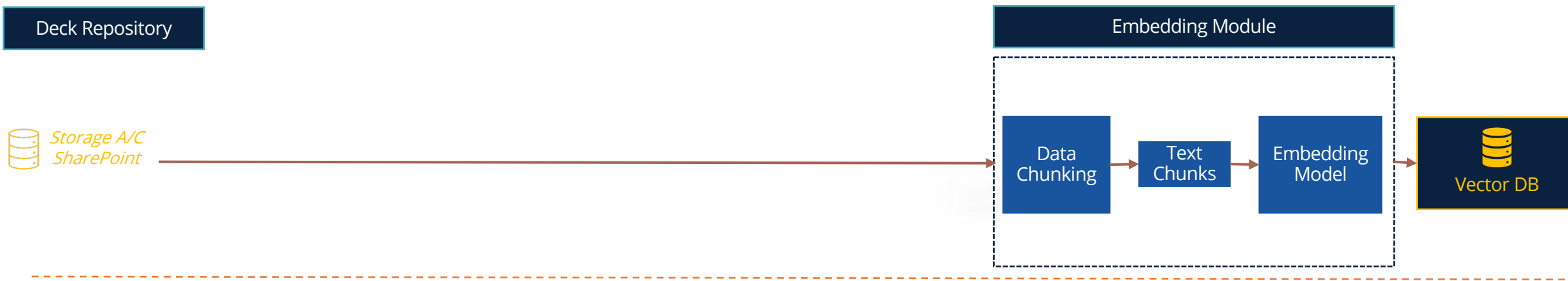
- Accuracy of the responses is still low.
- However, the output is much more human friendly
- Some control over output format



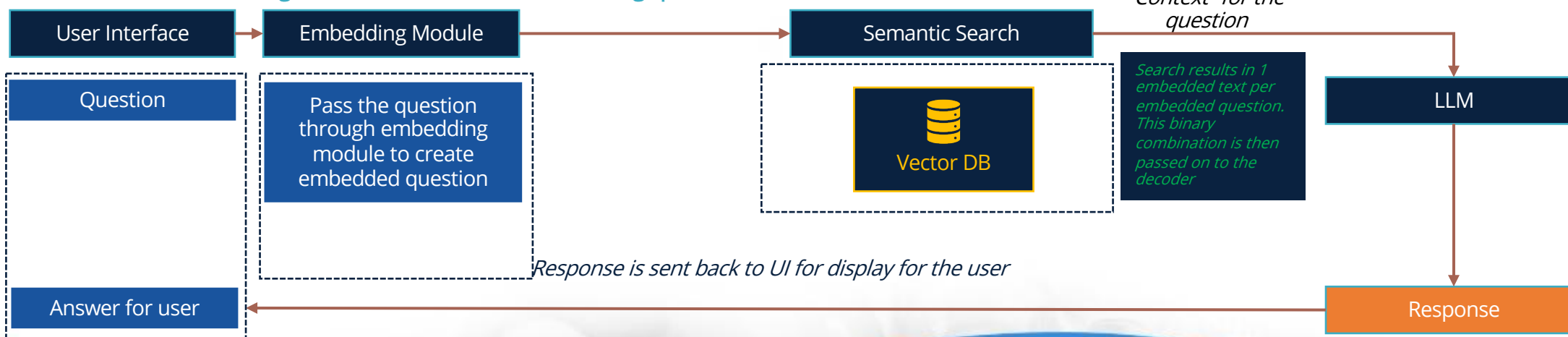


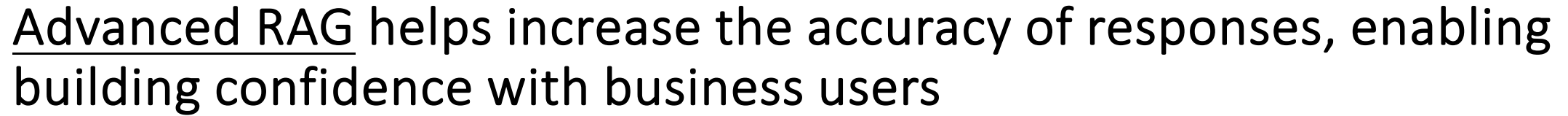
Architecture for Basic RAG

Batch Process: Enabling Semantic Search for Context



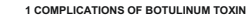
Realtime Process: Enabling user interaction and answering questions





1. Brow ptosis: Drooping of the eyebrows or eyelids.
2. Ectropion, diplopia, xerophthalmia, and lagophthalmos: Complications related to the eye area, such as drooping eyelids, double vision, dry eyes, and incomplete eyelid closure.
3. Lip ptosis and asymmetry: Drooping and asymmetry of the upper lip, leading to difficulties in speaking and eating.
4. Dysphagia, hoarseness, and neck weakness: Difficulty swallowing, hoarseness, and weakness in the neck muscles.
5. Asymmetry: Uneven results or imbalances in muscle activity, resulting in asymmetrical appearance.

Please note that this is not an exhaustive list of all possible side effects and complications associated with Botox. It is always recommended to consult a healthcare professional for personalized information and guidance.



Botulinum toxin acts by inhibiting the release of acetylcholine at the motor end plate leading to muscle paralysis. The selective paralysis of certain muscles is the basis of botulinum toxin treatment but paralysis of adjacent or other muscles can lead to the complications.

1.1 Brow ptosis

It is a common complication in the treatment of the foraminae mallei for addressing horizontal forehead lines with botulinum toxin. The complication can be avoided by staying at least 2–3 cm above the superorbital margin or 1–2 cm above the eyebrow while injecting the horizontal forehead lines. The technique requires the location of the inferior foramina mallei, the area between the premaxillary and maxillary foramina. In 12 patients where horizontal forehead lines are present along with glabellar brow lines, it is important that the glabellar lines are treated along with the forehead; otherwise, unopposed depression action of the glabellar muscles will lead to brow ptosis. 2.3 Patients who have a forehead line along with glabellar lines are also at risk of brow ptosis. The glabellar lines are treated with botulinum toxin to prevent repeat leading to weakening the lateral palpebrae superiors. It is commonly seen when botulinum toxin is injected close to the bony superorbital margin at the midglabella line and when large volumes of diluted toxin are injected in the area. 4.2 Lip ptosis can also be seen in patients who have a forehead line and glabellar lines. The glabellar lines are treated with botulinum toxin and the forehead lines are treated with the brow and the eyelids. With the weakening of this compensatory action of the frontalis by botulinum toxin, a secondary telephrynos can appear as per 4–6.

Exotropion, diplopia, anisophthalmia, and lagophthalmos cause complications such as exotropion, diplopia, anisoph-

weakening of the muscular support of the lateral orbitoticeles due to diffusion of the toxin. Ophthalmia can occur due to the diffusion of the toxin through the orbital septum leading to weakening of the lateral rectus and other extraocular muscles. Xerophthalmia can occur if the toxin is injected too deeply in the upper lateral aspect of the periculae area thereby affecting the secretion of the lacrimal glands. Lagophthalmos is another rare complication resulting due to the loss of the normal sphincter function of the orbicularis oculi, and the drooping down of the eyelids. Loss of the sphincter functions of the orbicularis oculi and eyelid weakness can occur when the toxin diffuses into the pupillary portion of the orbicularis oculi leading to lagophthalmos. These complications can be reduced by injecting the toxin subdermally and lateral to an imaginary vertical line that passes through the lateral canthus.^{1,2,6}

1.2 Lip ptosis and asymmetry

It is a rare complication seen when the toxin is injected below the superior margin of the zygomatic arch or too low along the nasal side walls thereby diffusing into the upper lip elevator, that is, levator labii superioris alaeque nasae and levator labii superioris leading asymmetry and ptosis of the upper lip and even difficulties in speaking and eating.⁷⁻⁹ Overloading of the toxin over the upper lip can cause many different adverse functional changes, which can include the inability to form certain letters, to articulate different sounds, and to pronounce various words. There can be inability to approximate the lips tightly, which can lead to fluid or even food incontinence and drooling.

1.3 Dysphagia, hoarseness, and neck weakness

Botulinum toxin treatment of horizontal rhytides and vertical bands in the neck is very safe, but complications can occur due to improper technique. As the underlying muscles of deglutition, phonation, and neck flexion are also cholinergic, higher doses of botulinum toxin deeper injection can result in aerostasis, dysphagia, dysphagia, and neck weakness.^{10, 11} A small number of patients may complain of either a difficulty or rarely an inability to lift the head and to keep it still and erect.

Document with Context

Summary:

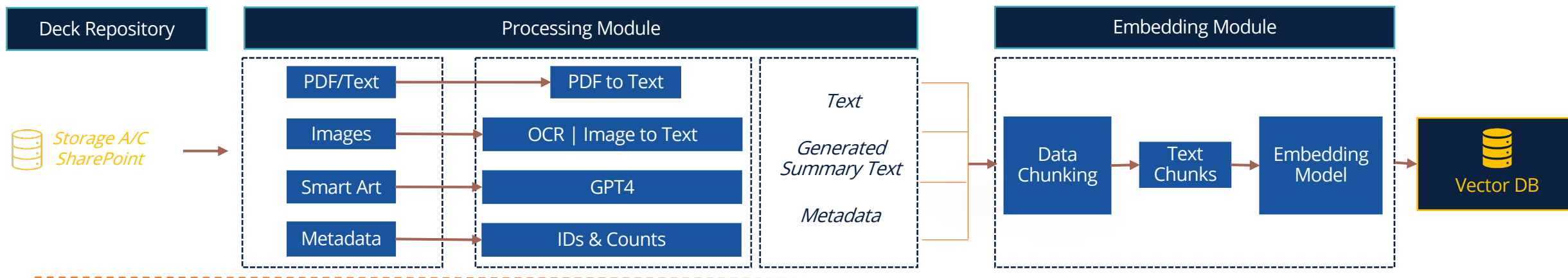
- Accuracy of the responses is very high
- Generated output is constrained to the context provided in the document above
- High control over output format



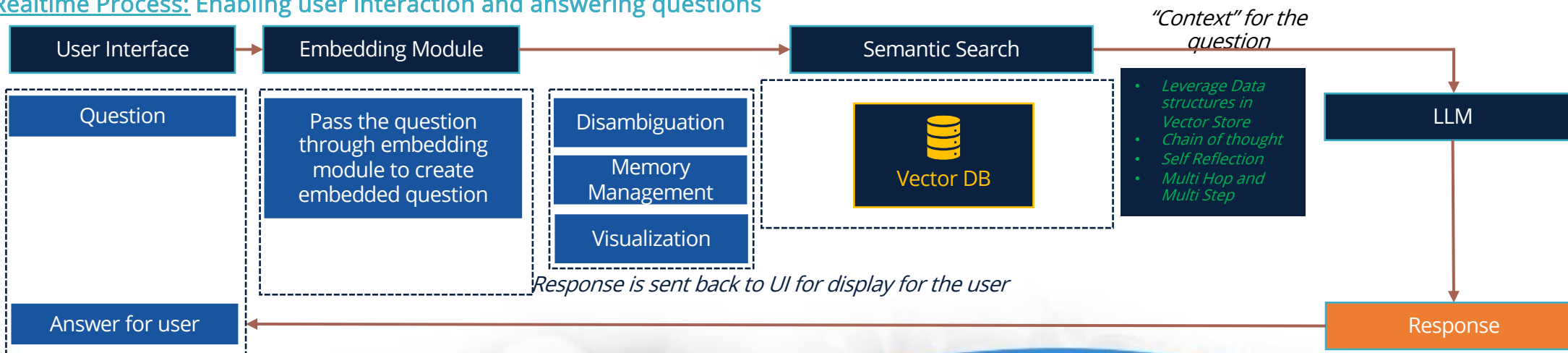


Architecture for Advanced RAG

Batch Process: Enabling Semantic Search for Context



Realtime Process: Enabling user interaction and answering questions





Knowledge Graphs can enable multi-hop Q&A

KNOWLEDGE GRAPHS FOR ADDING STRUCTURE TO “UNSTRUCTURED” AND ENABLING MULTI-HOP Q&A

Illustration

Primary research: Pfizer's PARP inhibitor combo treatment passes primary endpoint – but details are slim

“The study was also designed to look at two patient groups — those with HRR mutations and those without — though Pfizer did not share any details on the results in the two subgroups. Merck's Lynparza, also a PARP inhibitor, was approved for mCRPC patients with HRR mutations in 2020. Talzenna got its first approval in 2018 in advanced HER2-negative breast cancer with BRCA mutations — four years after Lynparza became the first PARP inhibitor on the market.”

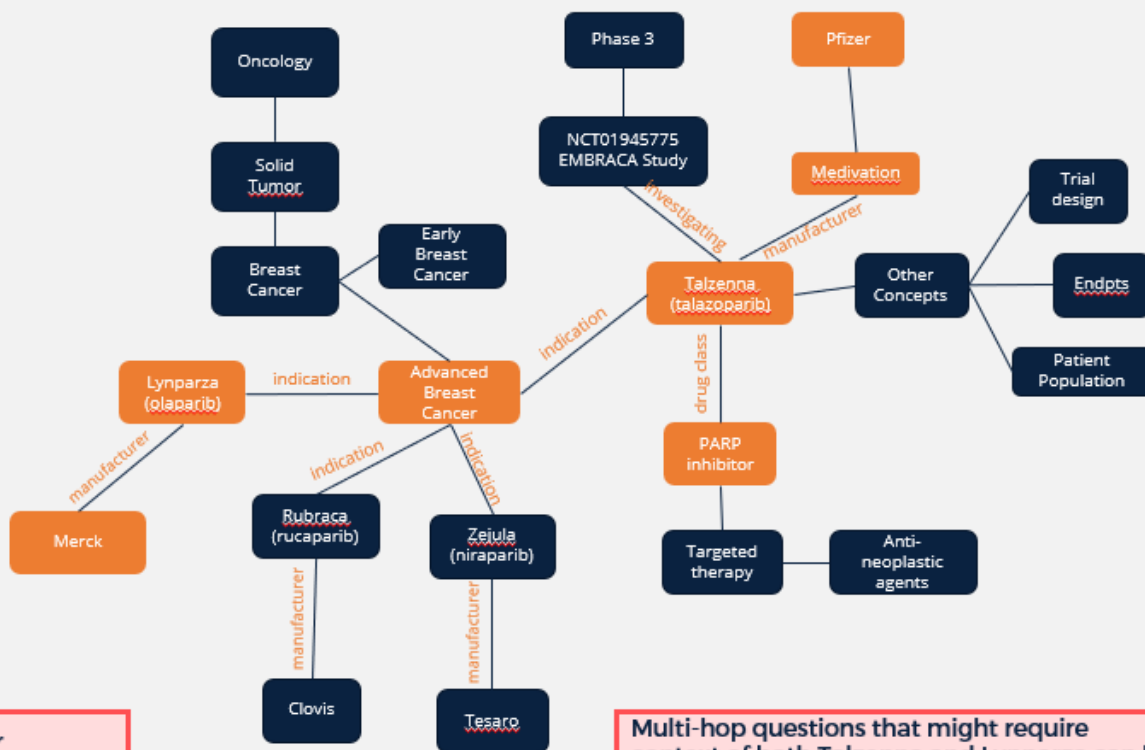
Entities :

- **Drug:** Lynparza, Talzenna
- **Drug Class:** PARP Inhibitor
- **Disease:** Breast Cancer
- **Company:** Merck, Pfizer
- **Biomarker:** HRR, BRCA, PARP

Extracting entities that can be further connected with individual structured data or other sources of external unstructured data

Multiple such documents

Transforming unstructured information to a knowledge graph (a collection of multiple documents)



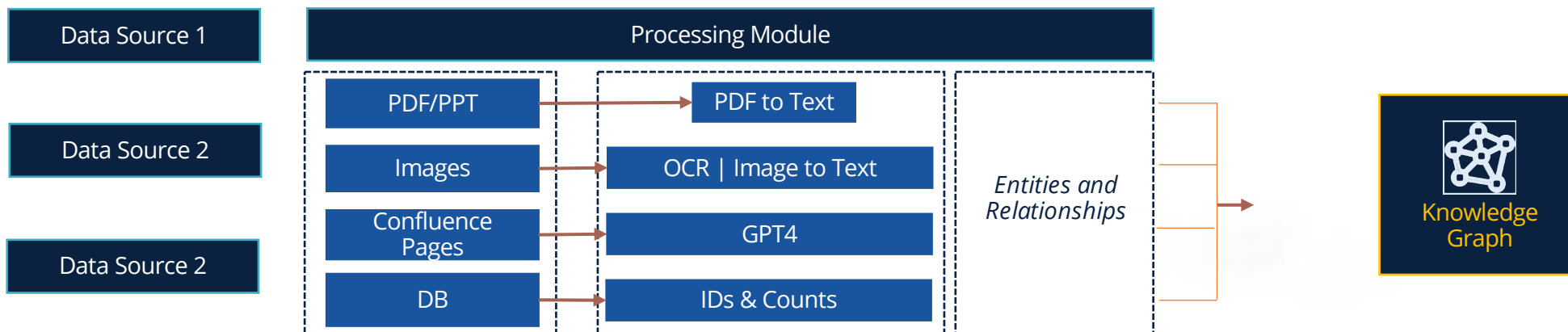
Multi-hop questions that might require context of both Talzenna and Lynparza can be connected via a shortest path depicted in orange



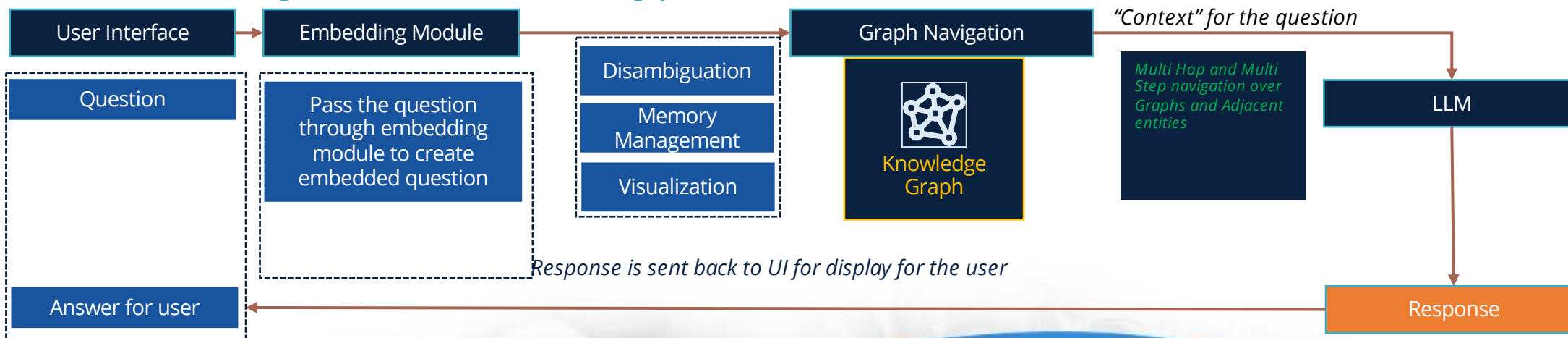


Architecture for Advanced RAG w/Knowledge Graphs

Batch Process: Enabling Semantic Search for Context



Realtime Process: Enabling user interaction and answering questions



Real World applications leveraging Conversational Capability can range from tech pilots to GenAI programs

Tech Pilot

Understand LLM's capabilities
Enable Text2SQL on a single database
Summarization of PDFs, PPTs

Business Pilot

Generating auto-insights on dashboards
Knowledge management & enabling data trust
Synthesizing Primary Market Research and Marketing Plans

GenAI Initiative

Q&A on Metadata, Metrics, etc. on an entire Data Lake
Improve conversability on complex questions
Sales Rep GPT

GenAI Program

Enterprise Conversational Analyst
- Data Discoverability
- Data Quality
- Analytics Ops
- Insight Generation
Connect Systems