POLITECNICO MILANO 1863

DATA SCIENCE LAB

ENERGENIUS
Smart Energy Solutions for a Better Tomorrow

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Enhancing Human-AI Collaboration through a Conversational Agent for Energy Efficiency

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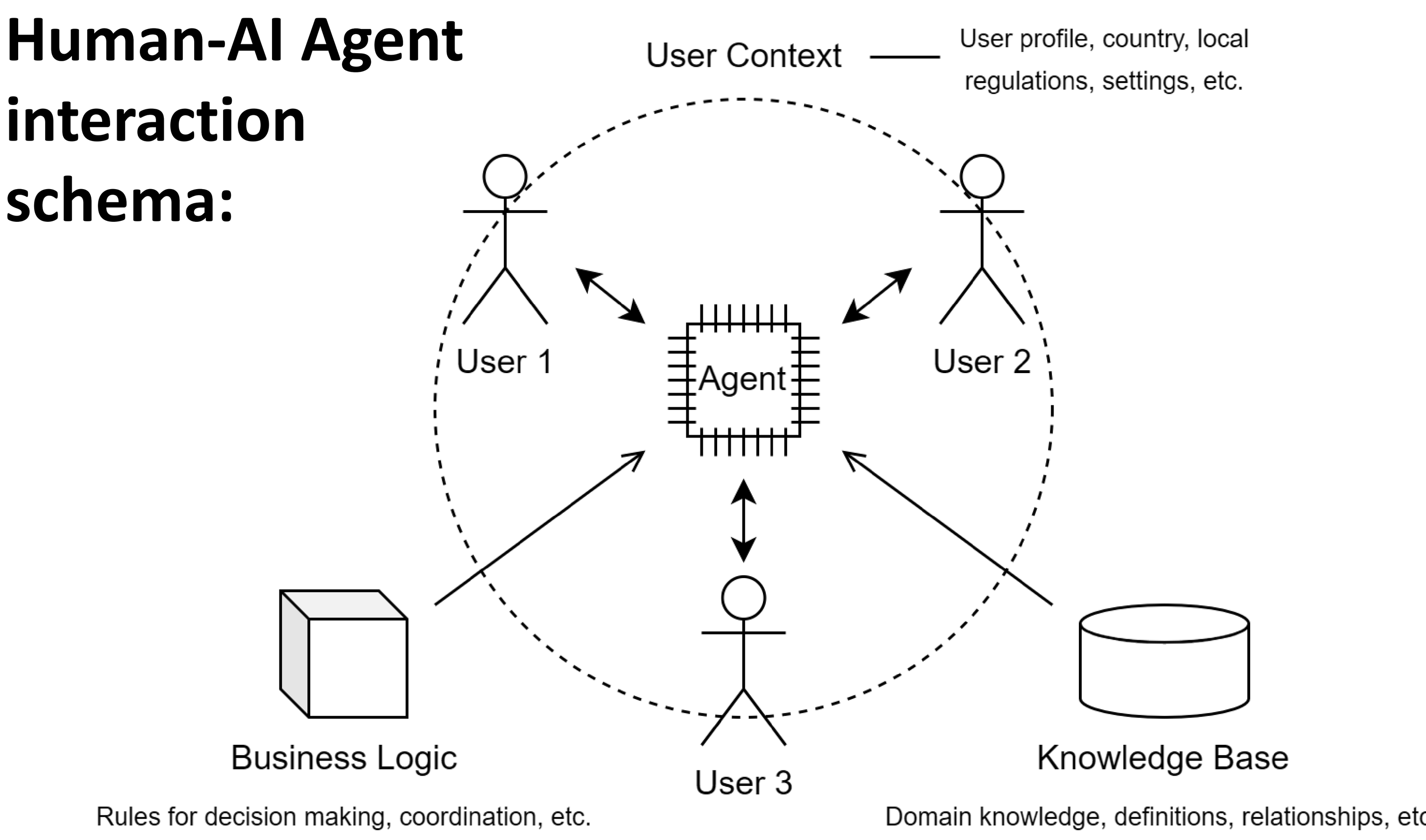
1 Background:

- **Energy Efficiency (EE)** is crucial for global sustainability goals such as **Net Zero Emissions**
- **LLM-based AI Agents** are effective tools to **interact** with users and **recommend things**

Goals:

- An **AI Agent** that **assists users** to reach EE by recommending them **efficient behaviors.**
- It must **adapt to humans** and ***augment* their capabilities**. It must consider communication and thinking **uncertainty**.

Human-AI Agent interaction schema:



2 Research Questions:

(inspired by Horvitz's concept of *Mixed-Initiative User Interfaces*)

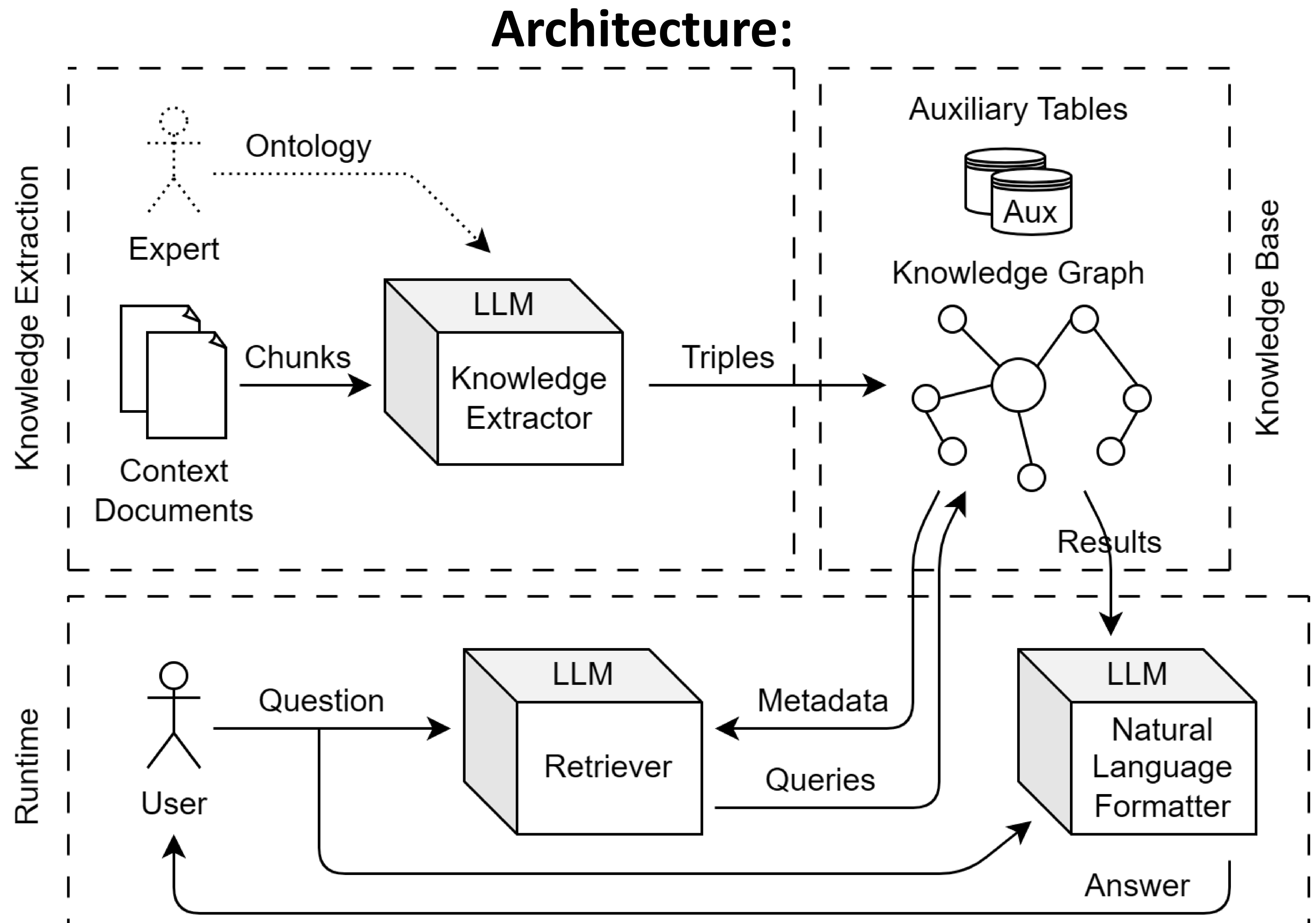
- **RQ1:** Does the AI Agent respond with **correct content**?
- **RQ2:** Does the AI Agent **consider context and uncertainty** about user? Can it **adapt?**
- **RQ3:** Is **user-agent collaboration efficiency optimized**?
- **RQ4:** Is the Agent satisfying **interactions' expectations** and **social rules**? Does it improve user-user interactions?

3 Principles:

- **Graph-RAG approach** for content retrieval
- Context-based personalization for relevance
- **Custom *Business Logic*** for decisions and coordination
- **Shneiderman's *Prometheus Principles*** for UI implementation:

(1) **consistent interface** to set intentions, (2) **visual display** of the **objects and actions** of interest, (3) **rapid**, **incremental**, and **reversible actions**, (4) **error prevention**, (5) **informative action feedback**, (6) **progress indicators**, (7) **completion reports.**

Architecture:



4 Interaction Flow:

- The AI Agent **receives a user question**.
- It **retrieves relevant information** from a *Knowledge Base* using a **Graph-RAG approach** and employs a *Business Logic* to guide and **optimize decisions** (e.g., focusing on community coordination).
- Finally, it **proposes an answer** to the user/community.

5 Evaluation Experiment Results:

- Domain experts are asked to **evaluate EE answers.** Evaluation criteria are taken from the **RAGAs framework**
- Questions are posed in both **Italian (IT) and English (EN)**
- Two context countries: **Italy (IT) and Switzerland (CH)**

		Context country:			
		Italy (25)	Switzerland (25)	Both (51)	All (101)
Language:	Italian (101)	$73.3 \pm 0.8\%$	$74.4 \pm 1.9\%$	$81.0 \pm 4.1\%$	$77.4 \pm 2.9\%$
	English (101)	$73.6 \pm 1.0\%$	$67.7 \pm 2.4\%$	$75.2 \pm 2.9\%$	$73.0 \pm 2.5\%$
	All (202)	$73.4 \pm 0.9\%$	$71.2 \pm 2.1\%$	$78.1 \pm 3.0\%$	$75.2 \pm 2.7\%$

Average RAGAs score

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