Ontology-Driven Interaction with Large Language Models: A Semantic Framework for Structured Context Injection and External Reasoning

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Figure 1: Seattle Mariners at Spring Training, 2010.

Abstract

This framework integrates ontological knowledge into decision-making processes involving large language models (LLMs) through the use of the Model Context Protocol (MCP) as a structured communication layer. A prototype application employs an ontology service based on the Basic Formal Ontology (BFO), extended through intermediate, application-specific ontologies that define roles, conditions, resources, actions, events, and capabilities according to standardized domain guidelines. Example implementations include the ProEthica application, which provides an environment for analyzing ethical decision-making by structuring role-based constraints and requiring agents to act in accordance with professional standards, and the A-Proxy application, which applies a distinct ontology to simulate persona-driven Web and chat interactions.

In the ProEthica implementation, the framework represents ontological structures as RDF triples, assigns each entity a persistent Internationalized Resource Identifier (IRI), and supports content negotiation for different RDF serialization formats based on client requests. To support the analysis of ethical decisions over time, ProEthica incorporates temporal modeling by extending RDF structures to represent ordered sequences of events and decisions. This enables the construction of a causal trace that records the temporal progression of actions and decision points without asserting underlying causality. The causal trace allows sequences of ethical decisions to be transmitted to LLMs in a temporally coherent structure, facilitating external reasoning about decision-making processes. In both ProEthica and A-Proxy, the ontology service supplies structured context to LLMs. This framework provides a method for aligning outputs from LLMs with formally defined knowledge structures by integrating symbolic semantic representations with statistical model behavior.

CCS Concepts

• **Information systems** → **Semantic web description languages**; • **Computing methodologies** → **Knowledge representation and reasoning**; **Natural language processing**.

Keywords

ontology-driven LLMs, Model Context Protocol, semantic web, knowledge representation, external reasoning, ethical decision-making

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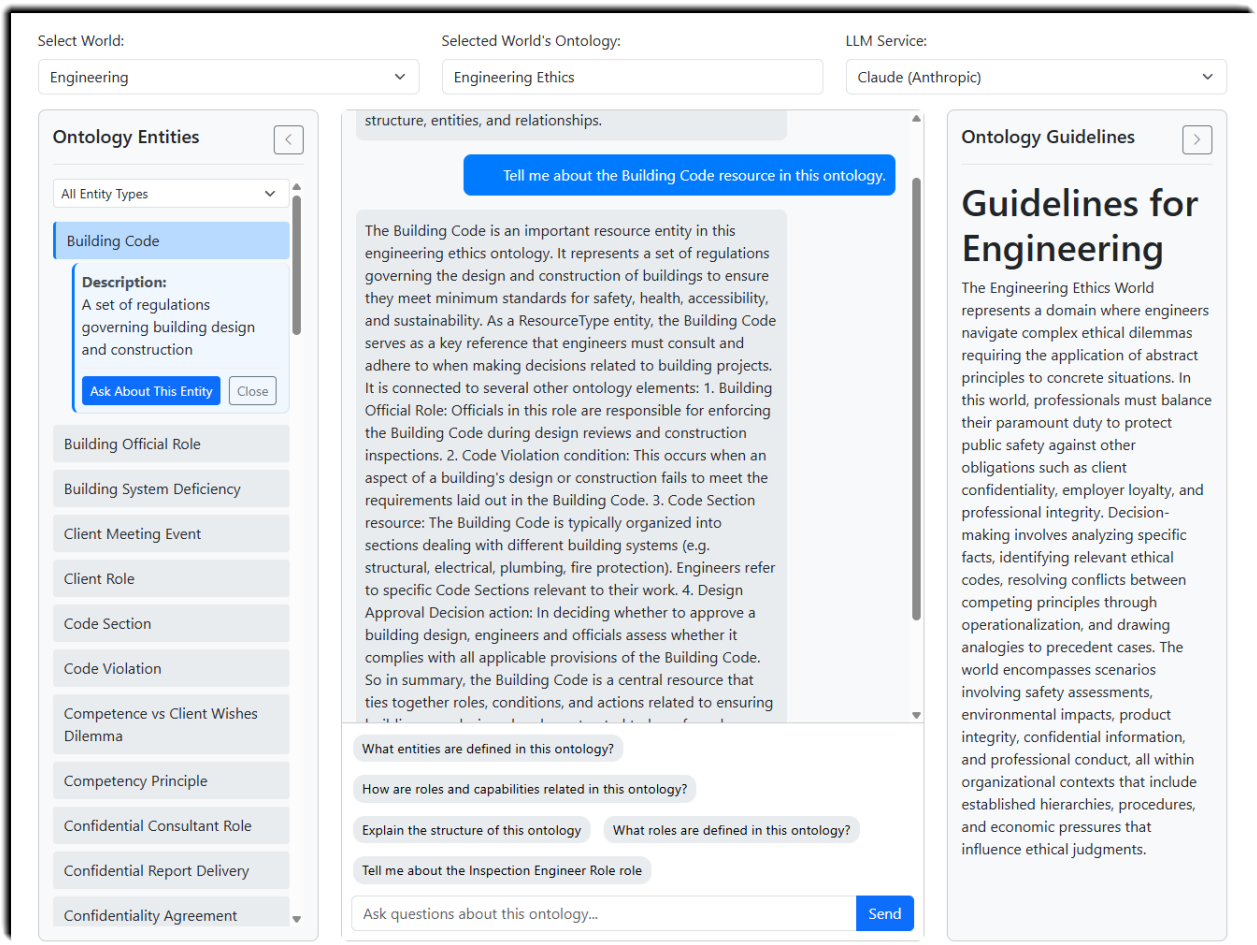

Figure 2: Interactive ontology-driven conversation enabling structured knowledge access through the Model Context Protocol. The interface allows users to explore ontological concepts and relationships while maintaining formal semantic constraints during LLM interactions.