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Editorial

Foundations Matter: The Role of Top-Level Ontologies in Knowledge Representation

In an increasingly data-intensive and digitally interconnected world, the science of *Knowledge Representation* plays a critical role in enabling machines and humans to structure, share, and reason about complex information. Ontologies – which are formal models that capture the concepts and relationships within a domain – have become essential infrastructure in artificial intelligence, information systems, and semantic technologies. Among ontologies generally, one type occupies a distinct and fundamental position: Top-Level Ontologies (TLOs), also known as foundational or upper ontologies.

TLOs operate at the highest level of abstraction. They provide domain-independent categories such as *object*, *event*, *process*, *quality*, and *role*, concepts that recur across scientific, social, technical, and cultural domains. Their purpose is not to model specific knowledge domains but rather to support the conceptual coherence, logical organization, and semantic interoperability of domain ontologies and metadata structures. For these reasons, TLOs have increasingly become central to ontology engineering, data integration, and cross-disciplinary semantic infrastructures.

The historical development of TLOs reflects the growing demand for formal, reusable, and semantically coherent structures capable of supporting cross-domain knowledge integration. From early proposals such as the *Suggested Upper Merged Ontology (SUMO)*, which focused on broad coverage and logical rigor, to cognitively motivated frameworks like *Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE)* and realism-driven approaches such as the *Basic Formal Ontology (BFO)*, foundational ontologies have evolved along diverse theoretical lines. Other contributions key to the development of TLOs include the *Unified Foundational Ontology (UFO)*, with strong applications in conceptual modeling and enterprise architecture; the *General Formal Ontology (GFO)*, grounded in formal ontology and systems theory; and *YAMATO* (*Yet-Another More Advanced Top-level Ontology*), which seeks to harmonize cognitive and engineering perspectives. Several of these have now been formalized in the *ISO/IEC 21838 series*; Part 2 (BFO), Part 3 (DOLCE), and Part 4 (TUpper) have already been published, and Part 5 (UFO) is currently under review. These prominent TLOs are noteworthy for having been standardized, though additional foundational ontologies also contribute meaningfully to the field.

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Selecting a foundational ontology is a theoretically weighty decision. It entails epistemological commitments that shape the ways that knowledge is organized, interpreted, and applied. Each TLO carries implicit assumptions regarding the nature of reality, identity, transformation, and classification. These assumptions directly influence the design and integration of domain ontologies. Thus, foundational ontologies are neither theoretically neutral nor interchangeable; they shape the semantic architecture of entire systems. Consequently, their selection should be guided by both conceptual coherence and practical relevance (Borgo et al., 2022). As discussed in previous work (Farinelli & Souza, 2021), foundational ontologies play a central role in promoting semantic interoperability, especially in large-scale information systems where conceptual reuse and alignment are essential. In this sense, TLOs function as conceptual infrastructures. They provide the intellectual scaffolding necessary for building coherent ontological ecosystems, enabling the reuse of well-founded modeling patterns and supporting consistent inferencing. Their importance is especially evident in contexts where multiple ontological modules must be aligned or where semantic interoperability is a central requirement. In ontology engineering, they offer methodological guidance for ontology alignment, semantic integration, and the reengineering of existing artifacts (Borgo et al., 2022).

Although domain-specific ontologies have proliferated into the thousands, many ontology engineering initiatives lack grounding in a top-level ontology, often relying on ad hoc conceptualizations that compromise semantic clarity and hinder interoperability. This widespread practice is increasingly recognized as problematic. The absence of foundational structure limits the potential for conceptual reuse and integration across systems (Farinelli and Souza, 2021), whereas adopting a foundational ontology fosters ontological coherence, improves reasoning capabilities, and supports the alignment of heterogeneous models (Borgo et al., 2022). Incorporating a well-established TLO is not merely a technical choice, then, but also a strategic one. It is essential for building robust, scalable, and semantically rigorous knowledge representation frameworks.

No single TLO offers a one-size-fits-all solution. The diversity of foundational ontologies reflects the pluralism inherent in knowledge representation. Different modeling goals and application domains call for different ontological stances. A TLO suitable for biomedical reasoning may not function equally well in cultural heritage, law, or linguistic annotation. Accordingly, selecting a foundational ontology requires carefully analyzing not only formal properties but also conceptual adequacy and alignment with domain needs.

Recent contributions emphasize that the choice of a top-level ontology constitutes an epistemological commitment that shapes how systems represent and interpret knowledge

AKR Advances on Knowledge Representation Journal

(Borgo et al., 2022). We therefore encourage researchers and practitioners to reflect critically on the foundational choices that underpin their systems. Instead of simply adopting the most familiar or widely used TLO, it is essential to evaluate each framework's philosophical assumptions, methodological commitments, and interoperability implications. Such evaluations strengthen not only our ontologies but also the integrity and explainability of the systems that rely on them.

This special issue of *Advances in Knowledge Representation* offers a timely opportunity to explore and reassess the role of foundational ontologies in both theory and practice. As artificial intelligence systems increasingly rely on formal knowledge structures to support transparency, reasoning, and integration, top-level ontologies become more important. The contributions gathered here reflect the richness and depth of current efforts, pointing toward a future of more reflective, principled, and interoperable knowledge representation.

We hope this issue serves not only as a reference for current researchers but also as an invitation to deepen our understanding of ontological foundations and to contribute to the ongoing dialogue about standards, methodology, and innovation in the field.

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