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PANORA: A Four-Domain Upper Ontology for Rule-Based AI and Semantic Knowledge Representation

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Abstract

Upper ontologies provide shared conceptual foundations for knowledge representation, semantic interoperability, and ontology development. However, established frameworks offer limited support for concepts whose interpretation depends on subjective experience, metaphysical commitments, or transcendent forms of existence. This limitation is particularly important in philosophical, theological, and humanities-oriented domains, where such concepts cannot always be adequately represented through a conventional Physical–Abstract distinction.

To address this gap, we analyze four widely adopted Upper Ontologies—DOLCE, SUMO, Cyc, and PROTON—and identify a common limitation in representing subjective, spiritual, and metaphysical concepts within a unified semantic framework. Inspired by the conceptual principles of **Mulla Sadra's Transcendent Philosophy (al-Hikmah al-Muta'aliyah)**, particularly the gradation of existence and the hierarchical organization of reality, we propose **PANORA**[1], a multi-layer Upper Ontology that systematically models physical, abstract, subjective, and transcendent domains while preserving their semantic relationships.

A preliminary qualitative evaluation based on semi-structured interviews with seven experts suggests that the proposed four-domain framework is conceptually coherent, while also identifying areas that require more precise formalization. The reported percentages represent descriptive patterns within this expert panel and are not presented as evidence of technical or logical validation. A preliminary OWL 2 DL[2] formalization of PANORA and accompanying HTML documentation are provided as supplementary materials.

Keywords: Upper Ontology, Ontology Engineering, Knowledge Representation, Conceptual Modeling, Mulla Sadra, Gradation of Existence.

I. INTRODUCTION

The rapid evolution of artificial intelligence over the past decade has been driven primarily by the emergence of large-scale foundation models, particularly Large Language Models (LLMs) [1]. These models have transformed natural language processing, computer vision, scientific discovery, and decision support by demonstrating unprecedented capabilities in learning from massive datasets and performing complex cognitive tasks. Their success has established a new paradigm in which increasing computational scale, model capacity, and training data are regarded as the principal drivers of intelligent behavior. However, despite these remarkable achievements, growing evidence suggests that scaling alone is insufficient for developing artificial intelligence that is explainable, trustworthy, controllable, and capable of robust reasoning in knowledge-intensive environments [2]. Recent surveys consistently identify hallucination, limited semantic grounding, weak explainability, poor reliability in out-of-distribution scenarios, and the absence of explicit reasoning as persistent challenges for current large AI models [3,4].

These limitations have renewed interest in integrating data-driven learning with explicit knowledge representation. Rather than viewing symbolic AI and neural learning as competing paradigms, recent research increasingly considers them complementary components of a unified cognitive architecture [5]. Within the emerging field of Neuro-Symbolic AI, ontologies, logical rules, and structured knowledge are used to constrain learning, improve semantic consistency, facilitate reasoning, and provide interpretable explanations while preserving the adaptability of deep neural models. Systematic reviews published during the past two years indicate that explainability, trustworthiness, semantic reasoning, and knowledge representation remain among the most important open research directions for next-generation AI systems [6].

[1] https://khosravi280.github.io/PANORA-Upper-Ontology

Among existing symbolic technologies, upper ontologies occupy a unique position because they provide explicit, machine-interpretable conceptual structures that remain understandable to human experts. Unlike neural networks, where knowledge is implicitly encoded within billions of numerical parameters, ontologies organize concepts, relations, axioms, and semantic constraints in a formal and verifiable manner. Traditionally, upper ontologies have been regarded as foundational artifacts for knowledge engineering and semantic interoperability. In the context of large AI models, upper ontologies may also provide a semantic foundation for future neuro-symbolic applications, including conceptual alignment, knowledge validation, and interaction between explicit and statistical representations [7]. The present study does not implement or test such an architecture; this possibility is considered only as a prospective application of PANORA.

In this article, the expression "Semantic Operating Layer" refers only to a prospective role that formal ontologies may play in future hybrid AI systems [8].

Ontology is a foundational concept in knowledge engineering, the Semantic Web, and artificial intelligence. It plays a key role in modeling the concepts, relations, and constraints of a knowledge domain. Classically, Gruber defined an ontology as "an explicit specification of a conceptualization," with the purpose of creating a clear, machine-understandable representation of a specific domain [9]. This definition, with its emphasis on the explicit semantics of knowledge modeling, has provided the basis for much subsequent research in ontology.

Studer and colleagues later extended this definition, describing an ontology as "a formal, explicit specification of a shared conceptualization" [10]. This definition places greater emphasis on the formalization and shareability of knowledge among human stakeholders and software systems. This distinction highlights the role of ontologies not only as modeling tools, but also as foundations for semantic interoperability [11].

As knowledge-based systems have expanded and the need for semantic interoperability among heterogeneous systems has grown, ontologies have become essential tools for facilitating knowledge sharing, automated reasoning, and data integration [10]. Within this framework, ontologies make it possible to separate domain knowledge from specific software implementations. They also increase reusability, conceptual clarity, and the extensibility of knowledge-based systems.

Despite these advantages, domain-oriented ontologies alone cannot address all requirements of knowledge modeling. Such ontologies usually rely on implicit assumptions, domain-specific perspectives, and modeling decisions that developers rarely document explicitly. These dependencies can lead to conceptual inconsistencies, semantic ambiguity, and reduced interoperability among ontologies developed in different domains.

As a result, when researchers integrate, compare, or align domain-oriented ontologies, the absence of a shared conceptual framework at a higher level creates significant conceptual and methodological challenges. This issue becomes especially evident in complex and interdisciplinary systems.

To address these challenges, researchers have introduced the concept of an upper ontology, or foundational ontology. Upper ontologies provide a set of highly general, domain-independent, and abstract concepts. Their purpose is to establish a shared conceptual foundation for developing and aligning domain-oriented ontologies [11].

These ontologies define concepts such as object, event, property, process, time, and space at a foundational level, functioning as a conceptual layer for harmonizing specialized knowledge structures. In this context, Guarino and Welty's work on the formal ontology of properties, and their introduction of meta-properties such as rigidity, identity, and unity, demonstrated how a foundational conceptual framework can support more coherent use of hierarchical relations and conceptual distinctions in ontologies [12].

Thus, upper ontologies play an important role in increasing semantic consistency, improving reasoning capabilities, and enhancing the interoperability of knowledge-based systems.

Despite the development of well-known upper ontologies such as DOLCE, BFO, and SUMO [13-15], fundamental challenges remain in conceptual coverage, ontological commitments, and compatibility with emerging applications. Differences in philosophical perspectives, application goals, and levels of abstraction have prevented any single framework from being accepted as a comprehensive and universal solution. Comparative studies show that each of these upper ontologies has its own strengths and limitations, and that the choice among them depends strongly on application requirements [16].

For this reason, introducing new perspectives in the design and analysis of upper ontologies is not only necessary but unavoidable, particularly when dealing with complex and interdisciplinary domains. Moreover, the emergence of technologies such as the Semantic Web, Linked Data, and new machine learning applications—which require richer, more explicit, and more expressive knowledge models—has further increased the importance of developing and rethinking upper ontologies.

Much of the existing work on upper ontologies is grounded in realist approaches and the Aristotelian tradition in ontology. These approaches focus mainly on entities assumed to exist as objective and mind-independent components of the external world—entities that can be modeled in a precise, stable, and observable manner. Basic Formal Ontology (BFO), for example, explicitly emphasizes ontological realism and defines its goal as describing the fundamental structure of reality independently of human cognition [14].

This view, rooted in Aristotelian metaphysics, rests on distinctions such as substance and accident, object and property, and stable entities versus processes [17]. Within this framework, BFO relies on the fundamental distinction

between continuants and occurrents and emphasizes formalized relations between these categories [18]. As a result, only concepts that can be treated as objective, temporally situated, and determinate entities fit fully into the structure of these ontologies.

This approach works well in domains such as the natural sciences, biomedicine, and engineering. Its limitations become clear, however, when it confronts abstract, interpretive, and trans-empirical concepts. Concepts such as meaning, intention, value, belief, and transcendent experience play a central role in the humanities, theology, philosophy, and cultural and social studies—yet these concepts are often either ignored entirely or modeled in a reductive and unsatisfactory way. In other words, whatever does not exist in physical reality but remains meaningful in human experience—such as transcendent entities, mental concepts, or imaginary structures—has no clear place in strict realist frameworks.

By contrast, some upper ontologies, such as DOLCE, adopt a cognitively biased approach that attempts to account for the role of perception, language, and human experience in the formation of concepts [13, 19]. From the outset, the developers designed DOLCE to describe the conceptual categories that appear in natural language and human cognitive structures [13]. Unlike the strict realism of BFO, this approach rests on the view that an ontology should reflect how humans understand and conceptualize the world, rather than merely the objective structure of reality [19].

Even within this approach, however, the main focus remains on concepts that can be explained within the framework of everyday human experience and linguistic context. The systematic coverage of transcendent, trans-empirical concepts—the kinds of concepts that matter in theology, mysticism, and deep cultural studies—remains limited. In other words, although DOLCE represents an important step toward conceptual flexibility, it still operates within a framework focused mainly on experienceability and linguistic describability; the developers did not design it specifically to model concepts with deeper interpretive, symbolic, or spiritual natures.

On this basis, we can argue that existing upper ontologies predominantly reflect strict realism and classical philosophical traditions. While these upper ontologies provide strong logical coherence and reasoning capabilities, they also neglect a broad range of human, interpretive, and transcendent concepts that are essential in many knowledge domains. This gap is especially evident in fields such as theology, religious studies, continental philosophy, literary criticism, anthropology, and cultural sociology, where concepts such as existential meaning, spiritual experience, and interpretive structures play a central role.

Moreover, in a contemporary world that faces epistemic pluralism and a diversity of philosophical and cultural perspectives, the need for upper ontologies that can systematically model this diversity without reductionism has become more urgent. Without such frameworks, knowledge-based systems in these domains either remain largely ineffective or must rely on ad hoc, unsystematic solutions.

In this study, we adopt an approach inspired by the humanities and Islamic thought to propose an extended upper ontology. This ontology moves beyond purely objective entities and enables the systematic modeling of abstract, semantic, and transcendent concepts. Our aim is not to replace existing upper ontologies, but to complement them—expanding their conceptual horizon and reducing the limitations imposed by strict ontological commitments.

The objectives of this study are therefore as follows:

- To review existing upper ontologies and examine their advantages and limitations.
- To examine the views of Islamic philosophers such as Avicenna and Mulla Sadra, and to determine whether existing upper ontologies represent such perspectives.
- To assess the feasibility of adapting existing upper ontologies to Islamic-Iranian culture.
- To propose an upper ontology aligned with Islamic philosophy and Iranian culture.

The remainder of this article proceeds as follows. We first review prominent upper ontologies and examine the philosophical foundations of the proposed upper ontology. We then describe the methodology and development process of this upper ontology and explain its underlying infrastructure. Finally, we present a summary of expert evaluations of the proposed upper ontology.

II. Literature Review

Ontologies play a key role in Artificial Intelligence and the Semantic Web as formal structures for representing knowledge. However, they face limitations in covering abstract, mental, and non-physical Concepts, such as meaning and spiritual experience in the humanities and theology. Classical philosophical perspectives, including those of Plato and Aristotle, and Islamic perspectives, such as Mulla Sadra's theory of substantial motion and Wasiti's mediating approach, have significant potential to enrich these frameworks. This section reviews the philosophical foundations and types of Ontologies, shows their limitations in covering Islamic–Iranian Concepts, and emphasizes the need to design a new hybrid Ontology.

A. Basic and Philosophical Theories

A foundational understanding of being and the existential structure of Entities has always formed the core of both Western and Eastern philosophy. The perennial question "What is that which exists?" has shaped the foundations of metaphysics and has directly influenced the theoretical frameworks of Ontology in computer science. This section examines two classical approaches from ancient Greece—Plato and Aristotle—as the philosophical foundations of modern Ontologies. It then analyzes two contemporary Islamic perspectives, Mulla Sadra's theory of substantial

motion and Abdul Hamid Wasiti's framework of networked understanding, as philosophical extensions of these classical foundations.

The philosophical framework adopted in this study is explicitly situated rather than intended as a universal account of metaphysics. PANORA draws primarily on Mulla Sadra's Transcendent Philosophy and uses Wasiti's networked account of meaning as a related interpretive framework. These sources were selected because they provide distinctions relevant to the proposed four-domain architecture, particularly the gradation of existence, the distinction between existence and quiddity, and the hierarchical organization of reality.

Plato's View: The Theory of Forms

Through the theory of Forms, Plato separated the world of truth from the sensory world. According to this view, true and complete reality belongs to a transcendent, non-sensory realm in which Forms, or Ideas, exist eternally, immutably, and immaterially. These Forms—such as justice, beauty, and goodness—are not only absolutely perfect but also serve as the source and model for all sensible phenomena in the physical world. By contrast, objects in the sensible world are only shadows or imperfect imitations of these Forms, as the well-known allegory of the cave expresses. Forms therefore have a higher degree of reality, while the sensible world remains transient, changing, and unstable. From this perspective, we can attain genuine knowledge only through pure reason, not through the senses.

This two-world approach provided a basis for distinguishing between intrinsic reality and sensory appearance.It also implicitly defined the Concept of Ontology as the search for fixed, universal structures that are independent of the material world.

Aristotle's View: Substance and Ontological Categories

While Plato located reality in the transcendent world of Forms, Aristotle criticized this view and sought substance and reality in the sensible world, within material objects themselves. He organized being into ten categories, including substance, quantity, quality, relation, place, and time, with substance serving as the foundation of all these categories. These two views shaped the foundations of modern Ontology: Plato's theory of Forms inspired High-level Ontologies such as SUMO, while the Aristotelian approach provided the basis for realist and domain-oriented Ontologies such as BFO.

Abdul Hamid Wasiti's View: A Networked Understanding of Meaning

Abdul Hamid Wasiti's view of a networked understanding of meaning, rooted in Mulla Sadra's Transcendent Theosophy, offers a theoretical framework for explaining the nature of meaning and the process of understanding. In this view, meaning is a living, networked Entity within being, and understanding is a systematic process of discovering Relations within this interconnected network. Wasiti's theory consists of six conceptual layers: ontological, epistemological, methodological, semantic, applied, and critical [20].

At the ontological layer, the theory rests on the assumption that being itself has a networked, dynamic, and Hierarchical structure, and meaning directly reflects this structure and follows its existential laws. At the epistemological layer, understanding means "discovering Relations": the interpreter moves back and forth between parts and the whole to reconstruct the author's mental space, ultimately aiming to reach the speaker's serious intended meaning. This approach stands in contrast to text-centered and historically oriented philosophical hermeneutics [20].

At the methodological layer, Wasiti draws three analytical tools from Islamic philosophy. First, the four causes—efficient, material, formal, and final—answer questions about what and why of phenomena. Second, the ten categories—quantity, quality, time, place, position, and Relations—make analysis more precise and concrete, especially when describing the formal cause. Third, the six constituents of motion analyze the dynamism and change of meaning. We can apply these tools not only to material Entities but also to abstract and constructed Concepts, such as purity and justice, provided that we take into account their real source of abstraction [20].

At the semantic layer, the structure of meaning gains several features. Meaning is not one-dimensional; rather, it includes a spectrum of levels, causal and coordinate Relations, and degrees of proximity and distance. Each meaning creates a "semantic field" of related Concepts around itself, and meanings are dynamic: they can grow, change, and transform, as if substantial motion also operates in the Domain of meaning.

At the applied layer, Wasiti offers an operational model for analyzing Concepts such as purity in jurisprudence. This model decomposes the Concept into the four causes, explains each cause through the ten categories, analyzes transformation through the constituents of motion, draws a comprehensive map of inputs, outputs, and critical points, and finally presents a multidimensional definition.

At the critical layer, Wasiti's innovation becomes clear in comparison with competing approaches. In contrast to philosophical hermeneutics, his approach is author-centered. In contrast to purely linguistic semantics, it emphasizes pre-linguistic existential structures. Compared with static Western ontologies, it offers an inherently dynamic and fluid view. The method of discovering meaning in this paradigm rests on the principle that meanings exist independently of the knowing subject: they are discoverable and have different dimensions, levels, and layers.

This method has practical applications in areas such as Qur'anic interpretation—including networked analysis of verses and religious Concepts—and the humanities, including the explanation of social and ethical Concepts. In this framework, a text is a coherent set of signs, and the smallest meaningful unit for understanding is the proposition or sentence. Understanding is the attainment of new awareness that results from discovering Relations among meanings already present in the mind: if the mind succeeds in discovering a Relation, a new sense emerges, and this sense constitutes understanding; otherwise, ambiguity arises.

The networked approach activates attention to the fact that the subject under study has interrelated components, goals, constant changes, and Relations with external variables. The main layers of the laws governing meaning are philosophy, which concerns the general laws of being; logic, which concerns the laws governing the mind; epistemology, which concerns the Relation between mental existence and external existence; and context, which consists of certain rational or empirical indications. Ultimately, every meaning has a semantic field—the first circle of related meanings—which connects to other fields. This chain continues until it reaches self-evident meanings [20].

B. Types of Ontology Classifications

The scientific literature classifies Ontologies according to different criteria. These classifications not only clarify the structural and functional diversity of Ontologies but also provide a methodological framework for selecting or designing an appropriate Ontology for a specific field. The most important classifications, discussed in authoritative works, revolve around three main axes: the degree of formality, the type of content components, and the level of abstraction and scope of application [11,21].

In the first classification, we divide Ontologies based on their degree of structure and formality. This approach places Ontologies along a spectrum, from the simplest term lists to the most complex formal logical systems [11,21]. Informal Ontologies, such as term lists, glossaries, and controlled vocabularies, include only terms and qualitative definitions and lack complex logical Relations. By contrast, formal Ontologies are built on Description Logic or First-Order Logic and fall into two subgroups:

- Lightweight Ontologies: These include Concepts, is-a Hierarchies, and simple Relations without complex Reasoning constraints [11,21].

- Heavyweight Ontologies: These include Axioms, semantic constraints, and automated Reasoning capabilities, such as Ontologies implemented in OWL [11,21].

Another important criterion widely used in the research literature is the level of abstraction—that is, the degree of generality or specificity [11,21]. From this perspective, we can describe the following types of Ontologies.

- High-level or Foundational Ontologies: These Ontologies include highly general and abstract Concepts that are independent of any specific Domain. They define Concepts such as object, event, time, space, and Relation at this level. Foundational Ontologies function as Upper Ontologies and provide a conceptual framework for developing other Ontologies.

- Domain Ontologies: A Domain Ontology models the Concepts and Relations related to a specific field from the perspective of a particular group of users or experts. This type of Ontology reflects how a phenomenon is perceived and conceptualized in a specific context and can serve as the basis for developing applied systems.

- Application Ontologies: Application Ontologies represent the most specialized type of Ontology and target a specific application. These Ontologies usually result from combining a Domain Ontology and a task Ontology, reflecting the perspective of a particular developer or user. Compared with other types of Ontologies, this type usually has lower reusability [11,21].

Classification of Ontologies Based on Level of Abstraction

Ontologies can be classified hierarchically, ranging from general concepts to specific ones, according to their level of abstraction. As illustrated in Figure 1, this classification typically includes:

- High-level (Upper) Ontologies**:** These possess the highest level of abstraction and offer the greatest degree of reusability across diverse domains.
- Domain Ontologies**:** These have an intermediate level of abstraction and are reusable within a specific domain or across several related systems.
- Application Ontologies**:** These have the lowest level of abstraction; they are highly specific and strictly dependent on a particular application or task.

In this hierarchy, as an ontology moves toward lower levels (from top-level to application-specific), its specificity increases while its reusability decreases.

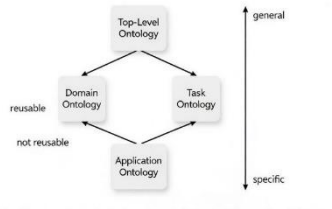

Fig. 1 Classification of ontologies based on their level of abstraction and generality

C. Ontologies Under Review

To design a comprehensive conceptual framework, we first need to examine and analyze existing Ontologies. Accordingly, we organize the Ontologies relevant to the present study into two categories: Upper Ontologies and Domain Ontologies.

1. Upper Ontologies

a. DOLCE+DnS Ontology

We examined the DOLCE Ontology, together with the DnS module, as a main candidate for the project architecture, since it distinguishes between persistent Entities, such as objects, and non-persistent Entities, such as events. It also supports the modeling of propositions and contexts [13]. We also studied the optimized version, DUL. However, when we

attempted to adapt this framework to mental, abstract, and transcendent Concepts—placing these domains on the same level as the physical domain—DOLCE faced challenges and introduced unnecessary complexity. Although several of its principles, such as the distinction between persistent and non-persistent Entities, had an indirect influence on our work, we did not adopt its direct architecture. Instead, we developed an independent and flexible structure [13].

b. SUMO Ontology

SUMO is one of the best-known Upper Ontologies [15]. IEEE developed it to provide a shared conceptual framework for integrating heterogeneous Ontologies. This Ontology covers thousands of domain-independent Concepts—including physical objects, processes, time, space, and abstract Relations—using the formal language SUO-KIF, and it enables logical Reasoning. Its key features include an open, standards-oriented approach, mapping to WordNet, and extended versions such as MILO. However, the complexity of its Axioms and the need for knowledge of First-Order Logic present challenges. We used this Upper Ontology in developing the abstract section of the present study [15].

c. PROTON Ontology

PROTON is a lightweight, modular, and domain-independent Upper Ontology developed within the European SEKT project [22]. The reference version we used in this study is Version 3.0 Beta (2011). This Ontology provides general Concepts for describing Entities, events, agents, topics, and places. Its location module enables precise modeling of the role of place by distinguishing among geographical, administrative, and functional places. In developing the PANORA Ontology, we used the PROTON location module to model spatial Concepts, since this module is more complete and flexible than those of other Upper Ontologies. This choice preserves simplicity while also ensuring semantic interoperability with other Ontologies [22].

d. BFO Ontology

BFO is a formal Upper Ontology designed to provide a shared conceptual framework for describing reality across different Ontologies [14]. Rather than focusing on a specific Domain, it defines fundamental and general Concepts that apply across all Domains. BFO organizes the structure of reality through basic ontological categories, so that Domain Ontologies can build upon it while avoiding conceptual inconsistencies. In the present study, BFO was considered as one of the reference frameworks used to examine upper-level distinctions and the role of formal relations [14].

e. GFO Ontology

GFO is a general Ontology with a philosophical orientation [23]. It aims to provide a comprehensive account of different types of Entities, changes, and the Relations among them. Unlike many Ontologies that adopt a static view, GFO emphasizes dynamism and transformation in reality and treats processes, changes, and flows as fundamental components of the world. This Ontology provides a conceptual framework for understanding phenomena as gradual and evolving. In developing the present Ontology, we drew on GFO as a theoretical source of inspiration for designing dynamic and transformable sections, and it helped shape the process-oriented perspective in the overall structure of the Ontology [23].

f. OpenCyc Ontology

OpenCyc is one of the most comprehensive basic-knowledge Ontologies [24]. Its developers designed it to model human understanding of the world and to serve as a shared language and common-sense framework for artificial intelligence. This Ontology includes hundreds of thousands of Entities and millions of logical Relations, and it represents fundamental Concepts such as time, space, causality, and objects using First-Order Logic. Its layered inference capability enables the extraction of implicit knowledge, improves semantic search engines, increases accuracy in text mining, and supports the management of complex knowledge networks. Using this Ontology moves information systems beyond pattern recognition and toward the capacity for logical analysis and content understanding [24].

2. Domain Ontologies

Researchers have developed prominent domain ontologies in several fields. In biology, the Gene Ontology (GO) serves as a reference standard for describing biological and genetic phenomena [25]. In Earth sciences, NASA's SWEET collection models natural and environmental concepts [26]. In event modeling, several ontologies stand out: REO, which is based on BFO and includes more than 160 event classes [27]; LACRIMALit, which focuses on historical crises [28]; and COfEE, which is designed for event extraction from Persian texts [29]. For temporal representation, Zhou and Fikes proposed a reusable time ontology for modeling temporal concepts and relations [30], while OWL-Time provides a W3C standard recommendation for representing temporal concepts and relations in OWL [31]. In the social domain, FOAF describes people and social relations [32], while IPO models the characteristics of human populations exposed to behavioral interventions [33].

Our review of these domain ontologies shows that although each is effective in its specialized domain, none of them adequately covers non-objective and internal concepts such as intention, belief, and emotion [25-33]. This gap reveals the need for a four-domain hybrid ontology, consisting of the physical, mental, abstract, and transcendent domains. The present study seeks to realize this goal.

III. METHODOLOGY

A. Designing the Conceptual Architecture: From Base Selection to the Formation of the Four Domains

The development of PANORA followed an iterative, expert-informed process of conceptual ontology design. The study did not adopt METHONTOLOGY or NeOn as a complete procedural framework. Instead, the development process consisted of a comparative examination of reference upper

ontologies, identification of conceptual coverage gaps, formulation of candidate classes and dependency criteria, expert consultation, and successive refinement of the proposed architecture. The revisions described below represent deliberate design cycles conducted in response to identified conceptual and structural problems rather than an unguided process of trial and error.

The initial motivation for this study came from the need for an ontological framework that is more inclusive and comprehensive than existing models. Our review of common Upper Ontologies showed that these models cannot fully cover a wide range of Entities, especially Concepts related to Iranian and Islamic intellectual traditions. The absence of a structured representation for Concepts such as transcendent Entities, religious doctrines, and specific philosophical ideas constituted a serious limitation. Moreover, most of these Ontologies had structures that limited their generalizability and their applicability to the diverse conceptual needs of users. The main goal of this project was to reduce this gap by designing and extending a new Upper Ontology that would offer broader coverage and enable the systematic inclusion of culture-oriented Concepts.

The work began with a comparative review of four foundational Upper Ontologies—Cyc, DOLCE, SUMO, and PROTON—conducted by the team members, who extracted the strengths and weaknesses of each model. In the first step, the team adopted an approach based on integrating these four models to achieve a more complete Ontology. This review focused on criteria such as conceptual coverage, structural flexibility, clarity of ontological Relations, and compatibility with trans-physical Concepts. Accordingly, the team created an initial hybrid model and then reviewed and revised it over several rounds.

This approach, however, faced two major challenges. First, the basic definitions across the different models were inconsistent, which prevented their smooth integration. Second, the resulting combination still failed to cover many Entities in the world, especially at abstract and trans-physical levels. In addition, a key design challenge involved choosing the type of hierarchical division to apply after the conceptual root, namely thing, in a way that avoided unnecessary complexity while properly preserving the nature of the models being integrated.

In the next step, the strategy shifted toward selecting a main core. Among the four models, the team selected SUMO as the basis. This choice was motivated by SUMO's greater structural flexibility, the simplicity of its hierarchical division into two main branches—physical and abstract—and the sufficient room it provided for extension. By contrast, the team considered Cyc unsuitable as the central core because of the direct and immediate connection of a large number of branches to the root and its excessive level of detail. The team did not select DOLCE because time plays a central role in the architecture of its division. PROTON was also considered unsuitable because of its less flexible structure.

After establishing the initial structure based on SUMO, the next development round attempted to add a "semantic network" layer as the first level of the Ontology, inspired by Dr. Wasiti's theory of the semantic network. In this design, the team divided this layer into subdomains such as "vocabulary." As the work progressed, however, it became clear that this approach was, in practice, moving toward the design of a Knowledge Graph rather than a formal Upper Ontology with a clear Hierarchy. The review also showed that once the team determined the type of Entity at the upper levels of this network, the need to complete the details and deeply develop the ontological Hierarchy weakened significantly. This contradicted the main goal of the study, which was to design a structured ontological framework. As a result, the team made the final decision to remove this layer from the architecture in order to maintain the focus on a purely ontological structure.

Alongside the technical design, the team strengthened the philosophical foundations of the work by studying Aristotle's theories on the classification of Entities and by examining the later development of these ideas in works such as those of Dr. Wasiti. The goal was to use these philosophical frameworks to address fundamental questions about the place of complex Entities and Concepts in the Ontology under design.

To translate these philosophical sources into ontological design elements, we identified distinctions that had direct implications for upper-level classification. These included the distinction between existence and quiddity, the gradation of existence, causal dependence, mind independence, and the relation of entities to place and time. We then expressed these distinctions as candidate class boundaries and dependency criteria and examined them against the structures of the selected reference ontologies. The resulting categories were refined through expert consultation and successive conceptual review. This process was interpretive and design-oriented; it was not intended to establish cross-cultural or universal validation of the underlying philosophical positions.

When the team began adding Iranian-Islamic Concepts to the two-branch structure of SUMO, its inherent limitations became evident. Many of these Concepts—such as transcendent Entities, phenomena of imagination, or the Concept of time itself—did not fit easily into the physical/abstract binary. The definition of the physical was limited to Entities dependent on space and time. As a result, the team moved anything that did not fit this definition by default to the abstract branch, which was incorrect for many of the cases mentioned above. This led to conceptual overlap, contradictions at lower levels of the Hierarchy, and a gradual decrease in the flexibility and precision of the model.

A fundamental need that intensified this crisis was our initial motivation to design a human-centered Upper Ontology. From the beginning, we intended to design a framework capable of comprehensively representing all dimensions of human existence, including the soul, body, and mind. In our view, many existing models were incomplete because they could not adequately include this totality, nor could they include the abstract Concepts related to human experience that did not fit into conventional branching structures.

In the next stage, after recognizing that many Entities did not fit properly into the physical and abstract branches, the team took the first step to address this challenge by expanding

the structure into three branches: physical, abstract, and mental. This change partly resolved some problems of overlap and incorrect classification. However, a new challenge emerged through consultation with an expert in the Islamic field and specialists in Islamic Ontology. Based on a review of different sources, these experts emphasized that Entities such as extraterrestrial beings, the human soul, jinn, or the Concept of God are not imaginary or products of the human mind and therefore do not belong to the mental domain. At the same time, under the existing definitions, these Entities could not be classified within the other two branches—the physical and the abstract—either.

This finding became a turning point in completing the conceptual architecture. To cover this category of Entities, which were neither physical, nor purely abstract, nor mind-dependent, the team recognized the need to define a fourth domain. Accordingly, they added the "transcendent" branch to the architecture as an independent domain, completing the logic of the final four-branch model. This domain was specifically designed to represent Entities that have an objective existence independent of the human mind, while at the same time not depending on place, time, or the laws of material physics.

B. Explanation and Development of the Four-Part Architecture

After considering these limitations, and after repeated consultations with specialists and several rounds of reconsideration, we arrived at a final solution in the form of a new four-part classification logic. The cornerstone of this framework is a novel pattern for dividing the first, or upper, layer of the Ontology. This pattern rests on five fundamental axes: "person," "structure," "causality," "place," and "time." By precisely defining whether each existential domain depends on these axes, this pattern identifies four distinct and coequal root Classes.

In this study, the cornerstone of the proposed Ontology is an innovative four-domain definitional framework that identifies and classifies each Entity based on its Relation to five fundamental ontological factors. These five factors are: the "first-person axis" (dependence on a knowing subject), "mental structure" (dependence on the rules or processes of the mind), "causality" (the capacity to affect or be affected), "place," and "time." Based on whether an Entity is "dependent" or "not dependent" on each of these axes, we define four distinct domains.

This fourfold classification creates a clear and understandable ontological map by providing precise definitions based on the five central axes. This map not only specifies conceptual boundaries but also, by focusing on the axis of “causality,” describes how these apparently separate domains interact with and affect one another. Consequently, it provides a solid foundation for developing a comprehensive and interdisciplinary ontology. The logical structure of this mapping is summarized in Table 1.

Table 1 Summary of the four-domain logic of the Upper Ontology

Realm	First-Person Axis	Mental Structure	Causal	Space	Time
Abstract	Independent	Dependent	Independent	Independent	Independent
Transcendent	Independent	Dependent	Dependent	Independent	Independent
Subjective	Dependent	Independent	Dependent	Dependent	Dependent
Physical	Independent	Dependent	Dependent	Dependent	Dependent

We define each domain through criteria that specify its dependence on, or independence from, the five fundamental axes. The four-part architecture was developed to address limitations of existing upper ontologies and the classification problems encountered in the earlier binary structure. By making the intended boundaries explicit, the framework reduces conceptual overlap and provides a basis for organizing transcendent, mental, and culture-oriented concepts. It also supports the human-centered aim of the study by bringing the dimensions of soul, body, and mind within a single conceptual framework.

After stabilizing this framework, we continued the development process through a division of work based on the four branches. Drawing on reference ontologies and relevant scholarly literature, we sought to represent a broad range of concepts and entities within a coherent hierarchical structure. The hierarchy underwent several rounds of review and revision. At one stage, a highly fine-grained approach and the creation of very narrow classes increased overlap and complexity. We therefore moved to more general class definitions in the following round, reducing unnecessary detail while preserving the conceptual commitments of the model. This iterative process produced a broader and more manageable hierarchy.

With this stage of development and revision complete, the design process—which had begun with the identification of coverage and structural gaps—came to fruition. It progressed through a critical evaluation of the base models, the structured development and assessment of an integrative approach, and the identification of its conceptual limitations, culminating in the high-level roadmap presented here. With these theoretical foundations in place, the next step was to translate the architecture into an implementable ontology by defining the internal structures, relations, and rules governing each of the four domains.

C. Five-Question Framework and the Overall Hierarchy

To translate this high-level architecture into an explicit classification framework, we first clarified the criteria governing it. The proposed organization uses five guiding questions, each addressing a distinct dimension of existence:

- Does the existence of this Entity depend on the perception of a specific knowing subject, namely the first person?
- Is this Entity a function of collective mental structures or norms?
- Does it participate in the causal network, with the capacity to affect or be affected?

- Is it located in place, or in physical/mental space?
- Does it occur in time, or within a sequence of events?

The combined answers to these questions create a transparent diagnostic mechanism that systematically directs each new Concept to one of the four main domains: abstract, physical, mental, or transcendent. Beyond guiding placement, this approach is intended to reduce conceptual overlap at the boundaries of the four domains.

a. Definition of the Main Classes

The design process for the ontology's class hierarchy begins with the root class Thing, which encompasses all possible entities. As illustrated in Figure 2, this root class branches directly into four primary conceptual chains, each representing a distinct domain of existence: Physical, Abstract, Subjective, and Transcendent. Each of these classes is further divided into a rich hierarchical tree of subclasses, enabling a systematic and granular classification of entities.

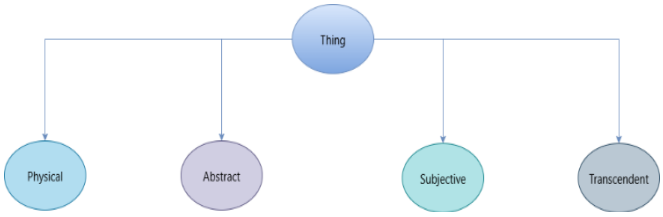

Fig. 2 The first level of the upper ontology

b. Physical

- *Definition and placement logic*

Entities in this Class depend on causality, space, and time, but are independent of the first person and mental structure. These Entities exist in the material world—that is, in spacetime—operate independently of the mind, and are subject to physical causal Relations.

- *Nature and examples*

The Physical class encompasses the domain of tangible objects, events, processes, and spatiotemporal regions. A physical entity may be an object, such as a mountain; an event, such as an earthquake; or a place, understood as a region of spacetime. In this ontology, the concepts of space and time are also modeled under this class as physical entities, since they function as objective substrates of the world and their existence does not depend on individual perception. As illustrated in Figure ٣, the Physical domain is divided into two primary branches: Occurrence and Object. Occurrence includes Spacetime Region, Time Intervals, Event, and Process, while Object includes Inanimate Object and Living Object.

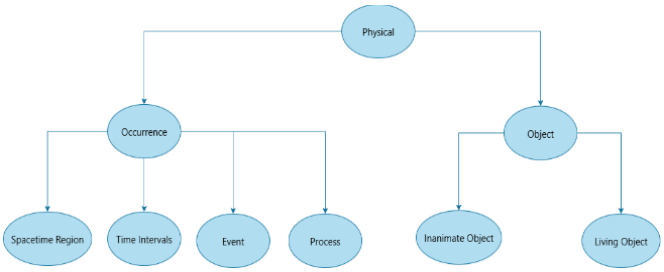

Fig. 3 Hierarchy of the physical class including its first and second levels

Example chains:

- Thing → Physical → Object → Inanimate → Device → Machine → Transportation Machine → Aerial → Airplane
- Thing → Physical → Occurrence → Event → Natural Event → Geological Event → Earthquake (Event)

c. Abstract

- *Definition and placement logic*

Entities in this Class depend only on mental structure and are independent of the other four axes: first person, causality, place, and time. In other words, these Entities are definable and meaningful only within the framework of an intellectual, cognitive, or conceptual system, without requiring a specific knowing subject, a physical cause, or placement within a spatiotemporal context.

- *Nature and examples*

The Abstract class encompasses the domain of features and properties that do not derive from a specific physical manifestation. Abstract entities are understood in a manner similar to mathematical objects, such as sets, numbers, and relations; they exist without requiring embodiment or physical representation at a specific time and place. As illustrated in Figure ٤, this domain is further categorized into primary subclasses including Quantity, Property, and Proposition, which cover elements such as mathematical propositions, logical concepts, linguistic grammars, and theoretical scientific patterns

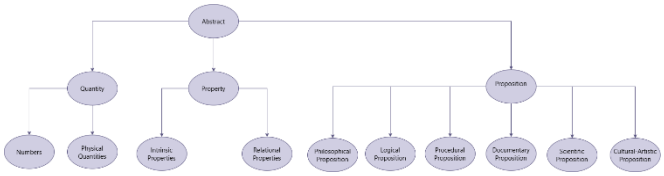

Fig. 4 Hierarchy of the abstract class including its first and second levels

Example chain:

- "Thing" → "Abstract" → "Quantity" → "Physical Quantities" → "Unit of Measurement" → "Second"

d. Subjective

- *Definition and placement logic*

  This Class represents Subjective Existence. We assign an Entity to this Class based on its dependence on the axes of first person, causality, place, and time, together with its independence from mental structure as an objective system. More precisely, these Entities refer to phenomena that arise through the direct experience of a knowing subject—the first person—within a specific context of time and place, and that possess the capacity to affect and be affected (causality) within the individual's psychological domain.

- *Nature and examples*

  The Subjective class represents the domain of perceptual forms and individual representations of external objects, concepts, or events. These entities lack stable objectivity and may change or disappear as the individual's mental state fluctuates. Their distinguishing feature is their non-shareability and their complete dependence on the individual's stream of consciousness at a particular moment. This nature is manifested in phenomena such as a sudden sensation of warmth or coldness, a fleeting mental image, or the sudden discovery of a meaning. As illustrated in Figure ٥, this domain is categorized into four primary subclasses: Mental States and Qualities, Mental Concepts, Mental Acts, and Mental Images.

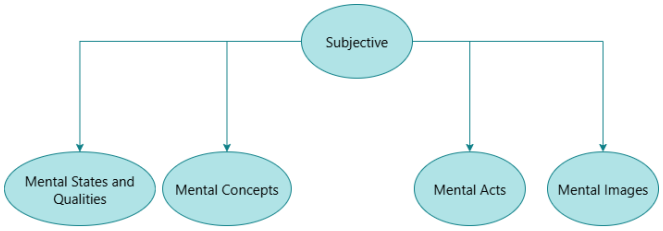

Fig. 5 First level of the subjective class and its primary subclasses

Example chain:

- *"Thing" → "Subjective" → "Mental Acts" → "Learning*

e. Transcendent

- *Definition and placement logic*

  Entities in this Class depend on causality but are independent of first person, mental structure, place, and time. This Class represents the domain of Entities that exist beyond the limitations of the physical and mental worlds.

- *Nature and examples*

  The Transcendent class is specifically designed to represent ultimate metaphysical and theological concepts within the Islamic-Iranian tradition. Entities such as the Divine Essence or supra-temporal creations belong to this category as realities that exist independently of individual perception and possess a fundamental causal capacity. This class enables the systematic integration of theological doctrines into a formal philosophical framework. As illustrated in Figure ٦, the Transcendent domain is structured into two primary branches: God (comprising Essence and Attributes) and Creations (including Spirits, Jinn, and Angels).

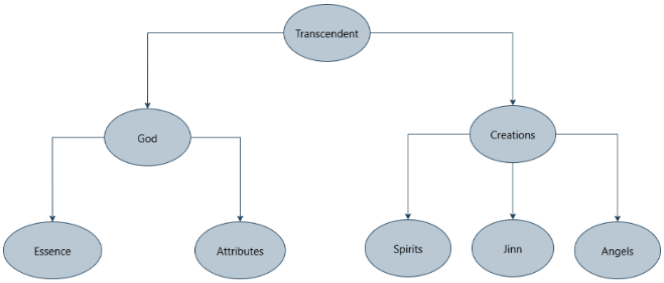

Fig. 6 Hierarchy of the transcendent class including its first and second levels

Example chain:

- "Thing" → "Transcendent" → "God" → "Attributes" → "Attributes of Action" → "Creation"

f. Design Considerations in Naming and Terminology

Developing an integrated Ontology that encompasses both universal Concepts and Concepts specific to Islamic-Iranian culture requires a systematic approach to the linguistic dimension. This dimension governs the precise modeling of the Relation between abstract conceptual structures and the ways in which natural language expresses them. A clear distinction between these two levels provides an essential foundation for the semantic annotation of texts, the execution of precise queries, and ultimately meaningful user interaction with the represented knowledge.

In the present Ontology, terminological precision has remained at the center of the construction process throughout. Selecting names for the Classes—especially the four main Classes, Physical, Subjective, Abstract, and Transcendent—posed a fundamental design challenge. These names had to satisfy three key criteria simultaneously:

a. Full alignment with the conceptual logic: Each name had to clearly reflect the position of the Class within the five-dimensional dependency framework—first person,

mental structure, causality, place, and time. This alignment ensures that the name functions as more than a label: it indicates the philosophical nature of the Class and the basis for distinguishing it from other Classes.

b. Conceptual breadth of coverage: The selected names had to cover a wide range of Instances, from fully universal and objective Concepts, such as physical objects, to specific, abstract Concepts rooted in the tradition of Islamic theology, such as divine acts. The names therefore had to be general enough to include all these subconcepts.
c. Reliance on authoritative sources: We had to support the selection of each name with documented and accepted sources in the relevant scholarly literature, to ensure the scientific validity and defensibility of the Ontology.

To address this multidimensional challenge, we carried out a structured comparative research process. For Classes with a universal nature, such as Physical and Abstract, we examined reference Ontologies such as DOLCE and SUMO, as well as large knowledge bases such as Wikidata, as primary sources. By contrast, for specialized Concepts rooted in the Islamic-Iranian tradition—especially the Subjective and Transcendent Classes—we consulted first-hand lexical and philosophical sources in Persian and Arabic, including authoritative dictionaries such as Dehkhoda and foundational texts of Islamic philosophy.

This research process resulted in a coherent set of conceptual labels (rdfs:label) in Persian. We selected these labels with high precision so that they would not function merely as literal translations, but would clearly reflect the definition, scope, and Relation of each Class within the overall conceptual network of the Ontology. This set provides a strong and defensible foundation for all future stages of development.

D. Design and Implementation of the Relation Network

After defining the four domains and their internal hierarchies, we turned to designing a network of Relations to connect the Entities of these domains to one another. These Relations—themselves mostly modeled as Abstract Entities—form the reasoning framework and semantic structure of the Ontology. The Relations we designed fall into major groups such as identity, generality and specificity, relativity (including quantitative, qualitative, spatial, and temporal Relations), opposition, causality, and value norms. These Relations make it possible to describe structural connections between any two Entities, even when they belong to completely different domains, such as a Physical Concept and a Transcendent Concept.

To make these relations machine-processable, the six relation categories identified in the conceptual model were represented as OWL object properties. Each object property was assigned Thing as its domain and range, allowing relations to be expressed between entities across the four upper-level domains. The formalization also uses rdf:type for class and property declarations, rdfs:subClassOf to represent the class hierarchy, and owl:disjointWith to define the four upper-level domains as pairwise disjoint. Together, these constructs make the intended organization and boundaries of the model explicit in the formal representation.

E. Resolving the Overlap Challenge and Design Summary

The most important challenge in designing this conceptual structure was the extensive and unintended overlap among Classes at the boundaries of the four main branches, as well as at lower levels of the Hierarchy. To address this issue and preserve conceptual distinction, we adopted the following solution:

F. Precise definition of boundaries based on dependency logic

For each class, we identified a set of distinguishing features based on the five-dimensional dependency matrix. These features serve as conceptual criteria for assigning new concepts to one of the four domains. For example, the Subjective domain is characterized by dependence on the first person, whereas the Physical domain is characterized by dependence on place and time. This approach is intended to make classification more transparent and to reduce overlap between the domains.

This coherent, multilayered design makes it possible to represent complex philosophical Concepts, tangible historical events, and religious doctrines within a shared conceptual framework while preserving their intended distinctions.

Overall, the proposed structure was developed to address the overlap and conceptual inconsistency encountered during earlier stages of the design. The five ontological axes provide conceptual criteria for distinguishing the four domains and organizing heterogeneous concepts within a common framework.

At this stage, the conceptual architecture has been expressed in a preliminary OWL 2 DL formalization, providing a machine-readable basis for technical inspection and further development. No reasoner-based consistency testing was conducted in the present study.

IV. EXPERT EVALUATION RESULTS AND COMPARATIVE ANALYSIS OF THE PANORA MODEL

A. Research Design and Composition of the Expert Panel

To assess the structural coherence, metaphysical adequacy, and formalizability of the proposed four-domain upper ontology, PANORA, we conducted a qualitative study based on semi-structured interviews with seven experts. Participants were selected through purposive sampling because their expertise addressed one or more of the technical, cognitive, and philosophical dimensions of PANORA, while the panel as a whole provided complementary perspectives. The panel comprised one specialist in ontology engineering with expertise in OWL 2 DL, description logics, and reference ontologies including BFO, DOLCE, and SUMO; one specialist in cognitive

science and psychology; one specialist in contemporary philosophy of mind with a research background outside the Islamic philosophical tradition; one specialist in Islamic theology and metaphysics; one specialist in comparative Western and Islamic philosophy, with particular expertise in Sadrian thought; one specialist in Islamic Peripatetic philosophy; and one specialist in Mulla Sadra's Transcendent Philosophy (al-Hikmah al-Muta'aliyah). Each interview lasted an average of 92 minutes. Before the interviews, participants were provided with an overview of the four-domain architecture, the five-axis dependency matrix, and the draft OWL constraints.

B. Theoretical Framework of the Analysis

We analyzed the semi-structured interviews using the Grounded Theory approach. Rather than testing predetermined hypotheses, this approach extracts Concepts and theoretical patterns directly from empirical data. The analysis proceeded in three stages. During Open Coding, we examined the interview text line by line and extracted initial Concepts. During Axial Coding, we organized related codes into main categories. During Selective Coding, we identified a core category that explains the other categories. This process led to a systematic extraction of themes and a coherent account of the experts' evaluation of the PANORA model.

The interview transcripts were coded by the primary researcher through the three stages described above. The initial coding framework and the resulting categories were subsequently reviewed with the supervising researcher as part of an analytical review process. Because the transcripts were not coded independently and in parallel by multiple coders, a formal inter-coder reliability coefficient was not calculated. This limitation should be considered when interpreting the findings.

C. Findings of the Three-Stage Coding

a. Stage One – Open Coding**:** At this stage, transcribed interview texts were examined line-by-line to extract initial codes without imposing prior theoretical assumptions. This process yielded 81 initial codes, which were subsequently reduced to 24 conceptual codes by merging repetitions and closely related concepts. To assess expert agreement, each conceptual code was evaluated separately. Table 1 presents the results of this evaluation.

b. The responses summarized in Table 1 show that all seven participants supported the distinction among the four domains and considered the hierarchy coherent. All seven also emphasized the need for explicit logical constraints. Other findings included an 86% alignment with the distinction between existence and quiddity, 71% endorsement of the possibility of representing the gradation of existence, and 86% agreement on the necessity of developing the causality model. However, 71% of experts highlighted the risk of oversimplifying transcendent concepts in cases of inaccurate formalization, and 43% noted relative ambiguity at the boundary between the Subjective and Abstract domains.

c. Stage Two – Axial Coding**:** At this stage, the 24 conceptual codes were organized into six main categories based on semantic similarity: "structural coherence," "metaphysical innovation," "alignment with Islamic wisdom," "necessity of precise formalization," "causality model development," and "boundary ambiguity." Table 2 illustrates the frequency of expert references to these categories. The results reveal that expert evaluations were organized around two primary poles: "theoretical coherence" and "the need for formal strengthening."

d. Stage Three – Selective Coding**:** The final stage aimed to extract a Core Category that provides a unified explanation of the findings. The analysis led to the following central theme: "The PANORA model is metaphysically coherent and innovative, but establishing its robust position in knowledge engineering requires more precise formalization and explicit specification of logical constraints." In summary, while experts regarded the model as philosophically defensible, they emphasized the necessity of completing its formal specification for system interoperability.

The percentages reported in Tables 1 and 2 describe the proportion of participants who supported or raised each point. They should be read as descriptive findings from a preliminary qualitative evaluation rather than as measures of technical performance, logical consistency, or formal validation. Because the panel was small and purposively selected, the generalizability of these findings beyond this exploratory stage is necessarily limited.

Table 1 expert evaluation results for conceptual codes and structural features

Evaluation Axis	Number of Agreements	Percentage	Analytical Description
Clear distinction of domains	۷out of 7	100%	Full consensus
Hierarchical coherence	7 out of 7	100%	Full consensus
Necessity of specifying logical constraints	7 out of 7	100%	All seven participants
Alignment with the Existence/Essence distinction	6 out of 7	86%	Overwhelming majority
Feasibility of representing the gradation of existence	5 out of 7	71%	Majority
Need for developing the causality model	6 out of 7	86%	Extensive emphasis
Concerns regarding the simplification of transcendent concepts	5 out of 7	71%	Significant warning
Relative ambiguity of the Subjective/Abstract boundary	3 out of 7	43%	Minority view

D. Metaphysical Innovation of the PANORA Model

The model's innovation can be analyzed at three levels. At the structural level, the model moves beyond the common Physical/Abstract binary and introduces four distinct domains: Physical, Abstract, Subjective, and Transcendent. At the metaphysical level, drawing on the philosophical framework of the study, PANORA provides a conceptual basis for representing the distinction between existence and quiddity and for the future modeling of gradation of existence, while treating the Transcendent domain as an independent foundational class. At the classification level, the four domains are distinguished through a five-axis dependency matrix covering time, place, causality, mind, and first-person dependence.

Table 2 Frequency of expert references to axial coding categories

Core Category	Frequency of Mention	Percentage of Experts
Structural Coherence	7	100%
Metaphysical Innovation	6	86%
Alignment with Islamic Wisdom	6	86%
Necessity of More Rigorous Formalization	7	100%
Need for Developing the Causality Model	6	86%
Ambiguity in the Subjective/Abstract Boundary	3	43%

E. Comparative Analysis with Reference Upper Ontologies

The comparative analysis of the PANORA model with reference upper ontologies (Table 3) indicates that this model **possesses** a broader metaphysical scope than DOLCE and BFO. Its principal distinction is the explicit organization of Physical, Abstract, Subjective, and Transcendent entities as four coequal upper-level domains. In terms of philosophical depth, it shows greater proximity to GFO, while remaining distinct from it through its explicit four-domain structure. This comparison concerns conceptual scope and design orientation rather than technical performance.

In particular, while most upper ontologies either omit the Subjective domain entirely or model it in a limited and non-independent manner, the PANORA model places this domain on the same level as the Physical, Abstract, and Transcendent domains. Moreover, the model is not committed to strict realism, and it represents transcendent concepts not implicitly or sporadically, but as a foundational ontological category.

Table 3 Comparative evaluation of PANORA with selected upper ontologies

Category	PANORA	DOLCE	BFO	SUMO	GFO	PROTON	Cyc
Four independent realms	✓	×	×	×	×	×	×
Independent mental layer	✓	✓	×	Limited	Limited	×	Scattered
Independent transcendent layer	✓	×	×	×	Implicit	×	Not explicit
Commitment to strong realism	No	Partial	Yes	Partial	No	Yes	No
Formal representation language	OWL 2 DL	OWL	OWL	KIF	OWL	OWL	First-order logic
Human-centric orientation	High	Medium	Low	Low	Medium	Low	High
Explicit metaphysical grounding	High	Medium	Low	Medium	High	Low	Medium
Formal disjointness constraints	✓	✓	✓	✓	✓	✓	Relative

V. CONCLUSION AND FUTURE WORK

The expert evaluation indicates that the proposed four-domain structure was viewed favorably within this panel. All seven participants supported the distinction among the four domains and regarded its hierarchy as coherent, while six of seven identified an alignment with the philosophical framework used in the study. At the same time, five participants cautioned that an overly simplified formalization could reduce the complexity of transcendent concepts. These findings provide preliminary support for PANORA's conceptual direction, but they do not establish its technical performance or logical consistency. Given the small, purposively selected panel and the absence of independent parallel coding by multiple coders, the findings have limited generalizability and should be interpreted within the exploratory scope of the study.

Future work will focus on further developing the preliminary OWL 2 DL formalization, evaluating it with standard reasoners, and refining the representation of causal relations and the gradational levels of existence. Further studies may also examine PANORA's alignment with Linked Open Data and its application in specific domains. The supplementary materials include PANORA.owl and PANORA_Ontology_Explorer.html; both files will also be made available through the project's public GitHub repository[3].

[3] https://github.com/khosravi280/PANORA-Upper-Ontology

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