**Risk-Oriented Ontology from Storylines**

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There are various definitions of ontology in computer science. We use the definition coined by Gruber (1993) and extended by Guarino (Guarino, 2009), which understands ontology as an explicit and formal representation of a domain with a shared ontological commitment. By using unambiguous computer language symbols, which need to be processed by computers, ontology-based models bring to light the semantics of things and the relationships between them, which often go veiled or ignored. Moreover, the ontological representation allows the sharing of an ontological commitment among stakeholders, which is a real agreement among them to achieve certain goals, such as 1) understanding better a portion of a domain; 2) improving by establishing a formal communication artifact between stakeholders and ontologists, and between stakeholders with different perspectives; and 3) Infer other knowledge based on an operational ontology, using a formal set of inference rules.

Since good ontologies are also perceived as artifacts built under an engineering method and based on foundational ontologies (Guizzardi, 2005), the result is a well-formed model with high expressivity, with the advantages of not being dependent on the data or databases and with the possibility of making inferences on it. Another result is a controlled vocabulary that can be shared between different ontologies or other computational structures or used by humans to better understand a part of a domain.

Furthermore, ontologies can be regarded as facilitating the interoperability of the semantics within a given domain. However, one issue that arises when discussing ontologies, ontological commitment, and semantic interoperability is the contextual shift that the engineering of technological artifacts has undergone in recent decades, i.e., from the development of conceptual models within a single organizational context to the development of these models in a heterogeneous organizational setting, with different perspectives. In a globalized and highly connected society, it may be the case that certain semantic artifacts could be more suitable than others. The question of how a '*quasi-universal conceptualization, an ontology, can be adopted to guarantee the interoperability of the data produced by historians'* has been raised by several scholars among them (Beretta, 2021). Indeed, the ontological commitment negotiated and accepted by a group of stakeholders in a specific context will not necessarily align with the ontological commitment accepted by other groups of stakeholders. The harmonization of these commitments represents a significant and challenging issue that requires careful consideration. We have observed that storylines can contribute to the integration of different perspectives when considering different narratives of a past or a potential future scenario.

Typically, ontologies are built using a top-down approach that focuses on finding the largest number of concepts and relationships in the domain being represented. Essentially, the top-down approach starts from the fragmentation of a system (whole) to promote understanding of the composition of its subsystems (parts). In this approach, we start from general concepts of the system to arrive at more specialized concepts. To guide this approach, we use a set of functional and non-functional requirements and a set of competency questions as well. For example, from the general concept of *infrastructure*, we arrive at concepts such as a *secondary road*.

In the Return project[1], we have conducted not only the top-down approach but also the bottom-up approach to build ontological models. The bottom-up approach starts from data, concrete concepts, and instances to abstract concepts. These concepts are generally context-dependent and application-specific. These kinds of concepts are present in some scenarios but may not be present in other scenarios of a domain. Aware of these limitations, the development of *risk storylines* (Zaccaria et al., 2024) was carried out during the meeting of researchers in Napoli in 2023. Parallel to the development of storylines on landslides, the engineering of an ontological model for the representation of risk-oriented urban systems based on the risk storylines was carried out. The results were compared with those of the top-down approach, which revealed the existence of concepts at more specialized

[1] https://www.fondazionereturn.it/en/

levels. On the other hand, the top-down approach presented abstract concepts derived from risk theories that were not perceived in the storylines.

Then, the resulting models were merged into a single one. Initially, it was found that combining both approaches in the ontology-building process resulted in more complete models that were more consistent with the perception of reality of the domain represented. Both models and their respective glossaries are available at https://gitlab.inf.unibz.it/earth_observation_public/CCT/pnrr-return/ts1 (first and second sprint of the ontology engineering).

The risk-based ontology of urban systems offers a realistic representation of events and processes that unfold over time based on the various constructed storylines. This enables analysis of a range of potential scenarios, including best-case (upward counterfactuals) and worst-case scenarios (downward counterfactuals), which could be useful in predictive scenarios where risk drivers occur concomitantly in a given urban area. Also, the combination of different approaches, guided by risk storylines, has demonstrated a significant improvement in comparison to the application of a single approach in ontology engineering, more specifically, ontology of risk storylines.

Regarding future works, we will conduct an empirical study with stakeholders to analyze requirements such as ease of use, comprehensibility, and model completeness generated in both approaches and in the hybrid approach. We will also continue the building of the ontology of risk storylines.

**References**

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