Mayukh Bagchi
Institute for Globally Distributed Open Research and Education (IGDORE), India.
University of Trento, Trento, Trento, Italy.

SEMANTIC KNOWLEDGE MANAGEMENT: TOWARDS A NOVEL KNOWLEDGE REPRESENTATION PERSPECTIVE

Abstract
The paper posits that there are *at least* five key interlinked representation levels which cumulatively inform the development of any Semantic Knowledge Management (SKM) model, namely, perception, language, ontology, taxonomy and description. To that end, drawing from concepts in knowledge representation, the paper illustrates how representation entanglement impacts the above representation layers culminating in an entangled final SKM model in an SKM exercise. Finally, the paper proposed a representation disentanglement approach to disentangle the aforementioned entanglement leading to the generation of a disentangled SKM model.

Introduction

Semantic Knowledge Management (SKM) has been defined as, quoting (Kalender and Dang, 2012), *"a set of practices that maintains data with its metadata in a machine readable format"*, usually, but not only, as SKM models like ontologies (Bagchi, 2021a) and ontology-driven Knowledge Graphs (KGs) (Bagchi, 2019a). To that end, there are *at least* five key interlinked representation levels (Bagchi, 2022) which cumulatively inform the development of any SKM model in an SKM exercise (Bagchi, 2019b; Das and Bagchi, 2025) irrespective of how it is instantiated in a use-case scenario. The first level is that of the perception of the actors and how they perceive the domain of concepts involved. Given the variety in perception, the second level is that of the body of terminology employed by the different actors (Bagchi, 2021b) to name the various perceived concepts involved in the SKM exercise. The third (representational) level is to ontologically characterise a perceived concept as, e.g., as dependent/independent, function or process, by the different actors. The fourth level is the taxonomy of concepts (Bagchi and Madalli, 2019) assumed by the different actors involved in the SKM exercise. Finally, the fifth level is characterizing the taxonomy in terms of interrelating and describing its constituent concepts via properties relevant to the SKM exercise. It is important to note that the ordered representation levels, as briefed above, complicates the conceptual modelling of any SKM model.

It is worthy to note that the aforementioned contextualization of SKM is *not* by chance. It is, in fact, a direct instantiation of the problem of *Representation Entanglement* (Bagchi and Das, 2022; Bagchi and Das, 2023) ubiquitous in knowledge representation research, whereby, it states that any conceptual model (e.g., an ontology for an SKM ecosystem) is representationally manifold by design and cannot be necessary as well as sufficient for all use-cases. First, there is always a *many-to-many* correspondence (hereafter, referred to as *representational manifoldness*) between entities and how they are perceived as concepts, e.g., in the context of an SKM exercise. Second, there is always a representational manifoldness between the perceived concepts and how they are named using a body of terms. Third, there is always a representational manifoldness between the named concepts and the way actors characterize them ontologically. Fourth, there is a representational manifoldness between the ontologically characterized concepts and how they are to be taxonomically classified. Fifth, there is always a representational manifoldness between the taxonomically classified concepts and how they are interrelated and described via properties. Finally, it is interesting to note how the impact of the representation layers magnify the entanglement in the final SKM model in an SKM exercise.

This paper advances a novel perspective of SKM based on knowledge representation termed as *Representation Disentanglement* (Bagchi and Das, 2022; Bagchi and Das, 2023). The key focus of the approach is to explicitly *disentangle* the decisions at each (knowledge) representation level mentioned before, which would otherwise *entangle* the final SKM model. The general approach, therefore, is to enforce *one-to-one* correspondence (termed as *representational bijection*) out of the possibly multiple representationally manifold possibilities at each level. To that end, first, the representational bijection between entities and their perception as concepts (e.g., by a particular set of actors) should be fixed. Second, given the fixation of perception, the representational bijection between the concepts and their naming via an interoperable body of terminology should be fixed. Third, given the fixation of terminology, the representational bijection between the labelled concepts and their ontological commitments, e.g., as dependent/independent, function or process, etc., should be explicated. In fact, an ontological characterization is key to disentangle the conceptual semantics which, otherwise, impedes techno-managerial interoperability in any SKM exercise. Fourth, the representational bijection between the ontologically characterised concepts and their hierarchical taxonomy should be fixed. Fifth, the representational bijection between each concept in the taxonomy and their interrelation and/or description via a set of properties should be fixed. Last but not the least, it is worthy to notice that the representation disentanglement is an iterative process and the disentanglement of the representation layers minimize the entanglement in any SKM model.

The remainder of the paper is organised as follows: The second section details the problem of representation entanglement across the representation levels and their confounding impact on any SKM exercise. The third section, on the other hand, elucidates the representation disentanglement approach across the representation levels and the way it minimises the entanglement and confusion in any SKM exercise. Finally, the fourth section concludes the paper.

Representation Entanglement in SKM

Let us now focus on how representation entanglement is implicitly but ubiquitously represented at each level within any SKM model.

First, let us concentrate on *perceptual entanglement* which occurs due to representational manifoldness amongst entities relevant for any SKM exercise and their perception as concepts which would eventually compose an SKM model. There are two key dimensions which influence the entanglement in perception of actors involved in the SKM exercise at this level. First, the very fact that *perception is egocentric* and can be unique to communities of practice. This premise leads to the notion of *perception as a cognitive filter*, i.e., in our terms, the fact that the same entity and its properties can be perceived differently by different sets of SKM actors depending on their goals and focus. There can be an overlap in the concepts perceived between, say, two sets of SKM actors and, equally, there can be ranges of mutual exclusion in their perception (e.g., due to different goals or focus). Second, the highly implicit consideration of perception in any SKM or KM setting almost leads to the underlying multiplicities of perception remaining unaddressed. It is also interesting to note the representational manifoldness between the same (SKM domain) entities and how they are variously perceived as concepts by different (sets of) actors involved in an SKM exercise.

Second, let us deliberate on *terminological entanglement* which necessitates representational manifoldness between perceived concepts and their naming using a term. A key cause of representational manifoldness at this level are occurrences of different linguistic phenomena. For example, polysemous terms naming a perceived concept provides at best an ambiguous notion of its meaning and magnifies the diverse interpretations and understanding for SKM actors involved in an SKM exercise. Further, with synonyms, the central problem is that of the establishment of mapping as it might not always be straightforward for SKM actors to infer whether two terms are same or synonymous or broader/narrower/distinct terms, leading to non-interoperability in communication and understanding. The above problems are further compounded in scenarios which might involve multiple languages and/or multiple communities of SKM actors.

Third, let us elaborate the notion of *ontological entanglement* which necessitates representational manifoldness between labelled concepts and their ontological commitment. There are two interlinked dimensions causing ontological entanglement. First, due to perceptual and subsequent terminological entanglement, different communities of SKM actors can perceive and label the same concept differently, thereby, bootstrapping the many-to-many mapping between different concepts and the different (top-level) ontological categories (Borgo, Galton and Kutz, 2022) they might potentially be categorised into. Second, as a consequence, different communities of SKM actors, unknowingly and implicitly, commit to the philosophical world-view of a top-level ontology, thereby, adding a second dimension to the occurrence of ontological entanglement. The ontological entanglement resulting in a multiplicity of representational manifoldness between named concepts and their top-level ontological characterization, in effect, translates into application-level implementational entanglements such as the management of interoperability and harvesting of metadata in networked SKM settings.

Fourth, let us now elucidate the *taxonomical entanglement* which necessitates representational manifoldness amongst ontologically characterised concepts and their taxonomic classification which would eventually constitute the backbone of an SKM model. There are four key parameters, from Ranganathan's faceted classification theory (Ranganathan, 1967), which induce taxonomical entanglement. First, with respect to a concept at a specific level of abstraction in the taxonomy, there are always multiple characteristics which can be employed to taxonomically specialise that concept into (potentially many) subordinate concepts. Second, the successive application of characteristics across the entire depth of taxonomy (with the possibility of multiple classificatory characteristics at each level of abstraction) leads to potentially infinite entangled classifications. Third and fourth, there can also be multiple ways in which concepts can be organised horizontally across a specific level of taxonomic abstraction (termed arrays in (Ranganathan, 1967)) and vertically across a taxonomic path (termed chains in (Ranganathan, 1967)), respectively.

Last but not the least, let us now elucidate the problem of *descriptive entanglement* which necessitates representational manifoldness amongst the taxonomic concepts and their interrelation and description via properties and/or attributes. There are two key dimensions which magnify representational manifoldness in this final stage for an SKM model such as an SKM ontology. First, during the final decision to characterise a property (uncovered at the ontological level) as an object or a data property, there exists a many-to-many mapping as the same property can be represented and refactored as an object or a data property depending on the purposes and goals to be served by the SKM model. Second, a concept in the taxonomy can be interrelated and described via multiple possible combinations of sets of object and data properties, again, depending on the precise purpose of the final SKM model.

Representation Disentanglement in SKM

After the elaboration of how representation entanglement is inherent, by design, at each representation level, let us now deliberate on the representation disentanglement strategy for designing an SKM model for an SKM exercise.

First, let us concentrate on *perceptual disentanglement* which enforces representational bijection amongst entities and their perception as concepts. There are different ways and means to achieve disentanglement at this level. First, a lightweight digital ethnographic exercise about the community and SKM actors and their perception about a domain can be of great help. Second, (digital) focus groups and/or one-to-one consultation with domain experts can also be employed to better understand a community's viewpoint about entities of a specific SKM domain. Further, independently or in addition to the above, an effort to reuse existing representation disentanglement documentations of similar SKM exercise can also be of help (thereby, reinforcing the iterative nature of disentanglement). Finally, the above inputs can be consolidated to validate/repair/enrich the initial perception and, hence, facilitate disentangling the perceptual entanglement.

Second, let us focus on *terminological disentanglement*, which enforces representational bijection amongst perceived concepts and the terminology. The guiding cardinal which can be employed for disentanglement at the terminology level can be referred to as the principle of usage warrant. It is based on the generalised notion of *warrant* in information science and can be understood as the principle to assign to a perceived concept a linguistically disambiguated and semantically explicit term which is based on the documented warrant and currency of SKM actors and users. To that end, each term label should embody standard terminological quality, e.g., having a natural language gloss, examples, identifiers, etc., to explicate its conceptual semantics. There are several (combinations of) options which can be exploited to achieve representational bijection of terminology, e.g., by consulting lexical-semantic resources, specialised glossaries, documentations and multilingual terminological standards.

Third, let us move to the next activity of *ontological disentanglement* which enforces representational bijection amongst labelled concepts and their ontological commitment. Notice that, similar to the disentanglement strategy at the terminological level, the general guidance of warrant is key to uncover the ontological commitment at this level. To that end, a multi-staged approach can be employed starting with bootstrapping an initial entangled version of the alignment of the SKM model with different state-of-the-art top-level ontologies. The outputs and documentation of focus group interviews and/or domain expert consultation and/or relevant representation disentanglement documentations can subsequently be examined to understand the ontological warrant of the community of SKM actors and users. The aforementioned results can enrich the best possible ontological fit amongst the different ontology alignments produced.

Fourth, let us concentrate on *taxonomical disentanglement* which enforces representational bijection amongst ontologically characterised concepts and their precise taxonomy. Given the general direction from the needs of the SKM exercise which would exploit the final SKM model, a disentanglement strategy can be designed to respond to the four stages of taxonomical entanglement. The solution is grounded in the canons of knowledge classification proposed by Ranganathan in his faceted classification theory (Ranganathan, 1967). First, the canons of characteristics (Ranganathan, 1967) like canons of relevance and ascertainability should be applied to eliminate manifoldness at the level of selecting a classificatory characteristic for specialising concepts at a specific level of abstraction in the taxonomy. Second, the canons of succession of characteristics (Ranganathan, 1967) like canon of relevant succession should be applied to disentangle the multiplicity existent in how classificatory characteristics are successively applied to design the conceptual depth of the taxonomy. Third and fourth, the canons of arrays and chains (Ranganathan, 1967) should be applied to disentangle the manifoldness existent while modelling concepts across a specific horizontal level and across a path of the taxonomy, respectively.

Last but not the least, let us move to the final activity of *descriptive disentanglement* which enforces representational bijection amongst the taxonomic concepts and their interrelation and description via properties and attributes. To that end, a two-step strategy can be formulated. First, a final decision on the exact split of properties in the SKM model into two distinct sets: a set of object properties and a set of data properties, should be achieved. This decision is critically influenced by the SKM applications driven by the warrant of a specific community of SKM actors and users. The next step is to make explicit the decisions on exactly how the object properties would be exploited to interlink the concepts in the disentangled taxonomy, i.e., determining the precise conceptual domain and ranges of the object properties. Further, perhaps most importantly, the exact set of data properties which should describe each concept in the taxonomy (also factoring in the taxonomic inheritance) should also be determined. Together, the above steps can facilitate a representational bijection and, thereby, generate the final disentangled SKM model.

Conclusion

To summarise, the paper presented a novel perspective on semantic knowledge management based on the knowledge representation notions of representation entanglement and disentanglement. Finally, note that the proposed approach has been validated through previous research on the development of SKM models in the domain of education (Das, Bagchi and Hussey, 2023), tourism (Das and Bagchi, 2025) and metadata development (Bagchi, 2024).

References

Bagchi, M. (2019a). A knowledge architecture using knowledge graphs. Master's thesis. Indian Statistical Institute, Bangalore, India.

Bagchi, M. (2019b). Smart Cities, Smart Libraries and Smart Knowledge Managers: Ushering in the neo-Knowledge Society. 50 Years of LIS Education in North East India.

Bagchi, M., & Madalli, D. P. (2019). Domain visualization using knowledge cartography in the big data era: A knowledge graph based alternative. In International Conference on Future of Libraries: Jointly organized by Indian Institute of Management (IIM) Bangalore and Indian Statistical Institute (ISI) Kolkata, Bangalore.

Bagchi, M. (2021a). A large scale, knowledge intensive domain development methodology. Knowledge Organization 48, no. 1: 8-23

Bagchi, M. (2021b). Towards knowledge organization ecosystem (KOE). Cataloging & Classification Quarterly 59, no. 8: 740-756.

Bagchi, M. (2022). A Diversity-Aware Domain Development Methodology. In the 41st International Conference on Conceptual Modelling (ER Conference). CEUR Proceedings, India.

Bagchi, M. (2024). A Generative AI-driven Metadata Modelling Approach. arXiv preprint arXiv:2501.04008.

Bagchi, M., and Subhashis Das. (2022). Conceptually Disentangled Classificatory Ontologies. In the 15th Seminar on Ontology Research in Brazil (ONTOBRAS). CEUR Proceedings, Brazil.

Bagchi, M., and Subhashis Das. (2023). Disentangling Domain Ontologies. In the 19th Italian Research Conference on Digital Libraries (IRCDL). CEUR Proceedings, Italy.

Borgo, S., Galton, A., & Kutz, O. (2022). Foundational ontologies in action: Understanding foundational ontology through examples. Applied ontology, 17(1), 1-16.

Das, S., Bagchi, M., & Hussey, P. (2023). How to teach domain ontology-based Knowledge Graph construction? an Irish experiment. Knowledge Organization 50(3), 182-201.

Das, S., & Bagchi, M. (2025). An ontology-driven knowledge graph for tourism information management. Open Research Europe, 5(1), 1.

Kalender, M., & Dang, J. (2012). Skmt: A semantic knowledge management tool for content tagging, search and management. In 2012 Eighth International Conference on Semantics, Knowledge and Grids (pp. 112-119). IEEE.

Ranganathan, Shiyali Ramamrita. (1967). Prolegomena to library classification. Asia Publishing House (New York).