Developing a Tool for PBO Design and Analysis: An Integration Between Enterprise Architecture and Project Management domains

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Abstract

Project-based organizations (PBOs) are loosely coupled, with significant decentralization of power that makes complex the alignment of projects, governance system and functional units. Moreover, projects are constantly changing in a PBO. Therefore, a solution for PBO design and analysis is needed to provide cohesion of a single design in constant remapping. Designing a PBO involves aligning strategy, structure, processes, organizational behaviour and people, as well as the project management (PM) practices and artefacts. However, the available tools to achieve this goal do not have an integrated overview between the organization and PM. Also, they are mainly in the form of a text guideline that makes its application difficult. In order to fill this gap, this research seeks to develop an integration between project management and enterprise architecture domains. The above is performed through a conceptual integration of the ArchiMate language for modelling the organizational architecture and the PMBOK PMs' body of knowledge, providing an alternative tool for covering the PBO design, analysis and modelling concerns. This integrated model has been developed through the semantic web that enhances computer querying and reasoning for its analysis. An evaluation has been performed through automatic ontology debugger tools.

Keywords
Project-based organizations, project management, enterprise architecture, ontologies, semantic web

1. Introduction

Organizations constantly seek to improve their operations, which are commonly conducted through projects (FM 2015). The impact of Project Management (PM) approaches in the organization presents various configurations (Lundin et al. 1995). In this regard, some organizations have PM as a part of the core processes to add value to their internal and external customers. They are known as Project-Based Organizations (PBOs) (Miterev et al. 2017 a; de Rooij et al. 2019). In the literature that studies PBO and PM, on the one hand, PBO has been conducted mainly from an organizational design perspective, understanding the PBO through the following interrelated components: Strategy, Structure, Processes, People and Behaviour (Atencio et al. 2022 a). On the other hand, the PM knowledge and practices have been addressed through time from a hierarchical decomposition of knowledge to an interconnected domain with a systems thinking approach (Atencio et al. 2022 a). For instance, this evolution can be observed in the recent Project Management Base of Knowledge (PMBOK) transition from the sixth to the seventh edition (Faraji et al. 2022).

From systems thinking, a tool for designing, modelling and analyzing an organization composed of interrelated elements is represented by Enterprise Architecture (EA), already developed from both theoretical and practical points of view (Lankhorst 2009). An EA is a set of principles, methods and models used to design an enterprise's structure through components such as business processes, information systems and IT infrastructure (Gonzalez-Lopez et al. 2019).

EA and PM are rarely connected in the literature (Gellweiler 2020) and the PBO design and analysis are not yet addressed through an EA perspective (Atencio et al. 2022 a). The advantages of EA for managing the organization have been recognized, such as enabling the organization for digital transformation, managing the organizational complexity, integrating standardizing and eliminating duplication of processes and systems and improving the governance and performance of projects (Foorthuis 2014; Niemi et al. 2020).

In a PBO, projects are continually changing. Tasks, information, and rewards are continuously remapped and reshaped for agents. Therefore, it is necessary to create and validate an approach that acknowledges this ongoing remapping and reshaping while preserving cohesiveness within the organization's requirements (Miterev et al. 2017 a).

A first step for giving an alternative solution is connecting the domains of PM and EA, which contains the organizational knowledge with the detail of their core processes mainly based on PM. To achieve this goal, a conceptual integration may be developed through models. Moreover, this integrated view of the EA and PM domain is not proposed in the literature yet (Atencio et al. 2022 a).

The integration of conceptual domains may be performed at a high level of abstraction using models (Werewka et al. 2010). PM and EA knowledge are summarised in several frameworks and languages (Atencio et al. 2022 a). In this regard, the widest-used references framework to be considered are PMBOK (Werewka 2018; Edition 2021) as a PMs' body of knowledge for PM and ArchiMate as a language for modelling an enterprise architecture (Aldea et al. 2015; Archi 2023).

This research develops a model that integrates PM and EA domains. The above, through a conceptual integration of the ArchiMate language for modelling the organizational architecture and the PMBOK PMs' body of knowledge to cover the PBO modelling, analysis and design concerns. This integrated model was created using the semantic web, which improves analysis through computer querying and reasoning. The use of automated ontology debugging tools has been used in order to evaluate the model.

The following contributions are expected from this work: (1) Contributing to theory filling the gap regarding the PM-EA disconnection. (2) Providing a tool for organizational design and automatic analysis suitable for PBOs. (2) Providing an integrated model based on the most used PM and EA framework: PMBOK and ArchiMate. (3) Provide a tool for managing the PBOs and project complexity.

2. Methods

The development method for this research is composed of two stages, as shown in Figure 1. Each stage is guided by a goal to obtain a set of outputs through developing a group of activities supported by tools.

The first stage seeks to understand the requirements for the proposed model development, whose purpose is to enable a semantic web-driven approach for PBO modelling, design and analysis. To achieve this goal, a literature review is performed to meet the state of the art about the applications of ontologies in PM, EA and PBO design concerns. The output of this stage is the selection of the existing ontologies (or development approaches) together with the PBO design requirements to be applied in the following stage. The second stage intends to develop an ontology-driven model. Based on the previous stage, the main considerations from the literature are applied in conjunction with an ontology methodology developed.

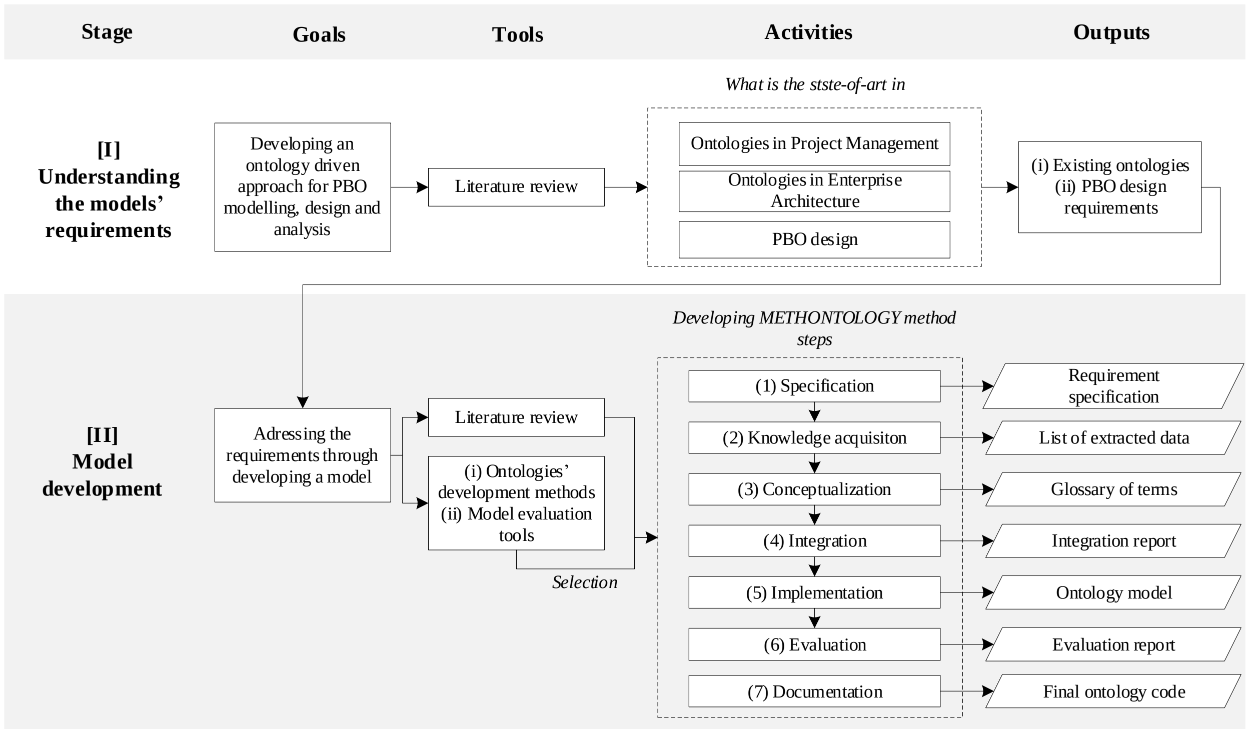

Figure 1. Development method

Ontologies serve as a specification mechanism to enhance knowledge sharing and facilitate reuse across various applications. The key objective of an ontology is to capture the meaning of concepts and statements within a specific domain (Borst et al. 1997). The ontology development process typically begins with constructing a model, and several frameworks have been proposed to aid in this endeavour.
One notable framework is METHONTOLOGY, which advocates a seven-step approach to ontology construction from a generic standpoint (Fernández-López et al. 1997). Another recent method, called "Ontology Development 101," has been developed by researchers at Stanford University and is specifically tailored for use with the Protégé ontology editor, the most popular open-source tool in this domain (Noy et al. 2017; Ferrarotti et al. 2018).
These methodologies primarily focus on two main objectives: model development and model validation. METHONTOLOGY has gained recognition for its outstanding approach and widespread popularity (Aminu et al. 2020). Additionally, it is known for providing an appropriate level of detail in ontology development (Jiang et al. 2022) and is considered highly mature in terms of its application (López 1999).
The METHONTOLOGY method – selected for this paper - is a widely recognized and popular approach for ontology development, known for its structured and comprehensive seven-step process. The first step of METHONTOLOGY involves crafting a detailed document that precisely defines the ontology's purpose, formality level, and granularity. This initial stage sets the foundation by establishing the desired level of detail within the domain.
Moving to Step 2, knowledge extraction takes place using various techniques, including expert interviews, text analysis, and model-based approaches. These methods help gather valuable insights and information necessary for constructing the ontology effectively.

Step 3 focuses on organizing the extracted domain knowledge into a coherent model. This involves summarizing a glossary of terms, which can be conveniently presented in tables. Through this process, a logical framework for the ontology begins to take shape.
In Step 4, existing ontologies are reviewed to identify reusable terms. This step accelerates the ontology creation process and enhances its quality. However, it is crucial to thoroughly understand the concepts within the ontology to ensure proper adaptation or translation of the reused terms.
Step 5 involves the codification of the ontology using specialized software tools. This step enables precise representation and implementation of the ontology, resulting in a tangible and usable artefact.

Step 6 focuses on evaluating the ontology by carefully reviewing the modelling language employed and ensuring the accuracy of the modelled domain concepts. This step serves as a critical quality assurance checkpoint, guaranteeing that the ontology aligns with the intended objectives.
Finally, in Step 7, all the outputs generated in the previous steps are synthesized and summarized. This final stage provides a comprehensive overview of the ontology creation process, facilitating a thorough understanding of the resulting ontology while ensuring alignment with the desired outcomes.

3. Literature Review

3.1 Ontologies in Project Management

PM can greatly benefit from ontology engineering as a core business process in Project-Based Organizations (PBOs), which enhances knowledge management and artefact reusability and ensures better consistency in process components (Fitsilis et al. 2014). In a recent review, Yang et al. (Borst et al. 1997) identified 11 main uses and benefits of ontologies, several of which have been applied in PM: *(i) Enabling interoperability and communication between stakeholders.* Filippetto et al. (Filippetto et al. 2016) proposed an ontology for allocating project resources, considering individuals, their skills, activities, and allocation rules. *(ii) Integration, mapping, exchange, and reuse of knowledge*. Integrating ontologies involves reusing existing models and concepts and has been useful in PM when integrating heterogeneous PM databases (Xing et al. 2008; Werewka et al. 2010). *(iii)Avoiding incompleteness and ambiguity*. Ontologies have addressed the complexity of project monitoring activities involving diverse companies, geographically dispersed PM teams, and data exchange between multiple applications (Hai et al. 2011). *(iv) Allowing domain knowledge representation.* PMBOK, a commonly used PM framework, has been employed for PM ontology development. For example, Zauga et al. (Silhavy 2019; Zaouga et al. 2019) developed a PM human resources ontology based on PMBOK's knowledge and mapped subdomains for a shared representation. *(v) Unifying vocabulary*. Project Management Ontology (PROMONT) (Abels and Ahlemann 2006) unifies different PM knowledge sources using an ontology-based on PMBOK and the German standard DIN69901 for PM. *(vi) Providing core concepts as a basis for describing other concepts*. Gaspoz et al. (Tereso et al. 2019) structured risk management concepts in PM to support managers and facilitate integration with software like Enterprise Resource Planning (ERP). Their research identified and modeled risk typologies and attributes. *(vii) Eliminating inconsistencies through homogenizing terminology*. Häußler (Häußler et al. 2021 a; b) proposed an ontology for standardizing knowledge in road projects, integrating it with a design authoring system. Similarly, Fernández (Fernández et al. 2019) addressed heterogeneity in energy efficiency project development by employing ontologies to harmonize software, databases, design guidelines, and stakeholder knowledge. *(viii) Providing a common understanding of a domain*. Various ontologies contribute to a common understanding of the PM domain. PROMONT (Abels and Ahlemann 2006) and the work of Bertol (Bertol et al. 2011) offer comprehensive overviews. *(ix) Capturing knowledge in a formal language*. The cited ontologies have been developed using ontology development frameworks like METHONTOLOGY (Fernández-López et al. 1997) or 101 Guide (Noy et al. 2017) and reusing other ontologies or domain frameworks. For instance, a teaching-oriented ontology based on PMBOK was described by (Sheeba et al. 2018). *(x) Managing complex logical axioms through machine-readable models.* All the mentioned ontologies facilitate automatic processing. In construction project management, ontologies have improved knowledge access and querying, resulting in significant time savings (Wu et al. 2021). These applications are also connected with the use *(xi)* of ontologies, which involves *providing a visual and navigable knowledge repository*.

3.2 Ontologies in Enterprise Architecture

The semantic web has been applied to EA and the major benefits can be found when defining and applying more complex analyses (Osenberg et al. 2015). In the literature, the following application can be identified. *(i) EA analysis*. This is the main use identified and is based on the fact that the complexity of EA models lacks representation schemes to make a computable evaluation, which makes their manual analysis difficult. Instead, ontologies allow the computational analysis of their models (Caetano et al. 2014; Bakhshadeh et al. 2016). Along the same lines as the need for computational analysis of an EA: when it is required to model and analyze an EA domain. *(ii) Modelling EA domain through ontologies.* Ontologies become useful for modelling and analyzing EA domains. For example, (Miranda et al. 2019) focuses on organizational capabilities. (Eshuis 2019)focuses on business processes. (Sales et al. 2019) seeks to disambiguate the concept of value in an EA (Detoni et al. 2017) and uses ontologies to represent the information systems domain for further integration. *(iii) EA integration.* Considering the possibility of performing a computational analysis on an ontology, these are used to integrate different domains of an EA and nine articles focus on this task. Following (Bakhshandeh et al. 2013), ontology integration comprises three processes:

- Ontology mapping involves building a new ontology by searching for common concepts between two (or more) concepts belonging to two (or more) different ontologies.
- Ontology alignment corresponds to constructing a new ontology by identifying correspondences between all concepts of two ontologies considered equivalent.
- Ontology is the process of building a new ontology by merging several ontologies into one, creating a more general ontology.

Applying the strategies above, this group of papers present the results of ontology integration for different purposes. For example, (Bakhshandeh and Pesquita 2016) integrates Archimate and BPMN. (Martin et al. 2013) integrates project knowledge domain with ArchiMEO, ontology developed from ArchiMate. (Bakhshandeh et al. 2013) integrates an ontology based on Archimate with UDO (Upper domain ontology) and DSO (domain-specific ontology).
(iv) *Developing an EA ontology*. Ontologies have also been used to represent (at a high level) enterprise architecture frameworks. (Hinkelmann et al. 2020) shows how ArchiMEO has established itself as an EA ontology and has been extended to other domains, such as projects and risks. This ontology has recently been cited and is available in OWL for use.

3.3 PBO Design Concerns

Organizations whose work is predominantly or completely performed in projects are commonly known as PBO (Eriksson 2013). Its research has captured the attention of different scholars and perspectives with increasing productivity (Atencio et al. 2022 a). In this regard, a wide range of studies have covered different PBO concerns, such as the study of capabilities to face the PBO dynamism (Melkonian et al. 2011), knowledge management (Lindner et al. 2011), the learning processes across the PBO and its environment (Wiewiora et al. 2020), or the appropriate performance systems to be applied in this type of organization (de Rooij et al. 2019) and the composition of a PBO as a specific type of organization (Miterev et al. 2017 b). This last focus of the study is possibly one of the most interdisciplinary, considering that it links the field of organizational theory with project management (Miterev et al. 2017 a). A PBO as a type of organization - compared to others - has certain characteristics that entail specific ways to manage them. For instance, projects and programs (as the core of a PBO) are conceived as temporary organizations (Lindner et al. 2011; IPMA 2016). Temporary organizations form to accomplish an ex ante-determined task with a predetermined termination point. They can be intra-organizational, occurring within the context of a non-temporary organization, or inter-organizational, comprising several organizations (Schüßler 2017). Very often, temporary organizations, such as projects, are formed in permanent organizational settings and embedded in structures such as networks, regional clusters, or organizational fields. Therefore, the boundaries between temporary and non-temporary organizations are quite fuzzy (Schüßler 2017). For instance, this situation can be observed in construction companies (Di Vincenzo et al. 2012).
Therefore, the design and analysis of PBOs may consider a proper perspective in order to orchestrate its complexity. The above sets the main need, considering an organization may be understood as a landscape of tasks, goals and information flows (Puranam et al. 2014). However, in a PBO these components are in permanent remapping a well, the projects as their temporary property. Therefore, a design solution for this situation needs to provide cohesion within the organization (Miterev et al. 2017 a). Different holistic models for organizational design have been developed over time, such as the Minztberg proposal (Mintzberg 1989), the Nadler & Tushman's congruence model (Nadler et al. 1999) and the Galbraith's Star-Model (Galbraith 2007). The study of Miterev et. al (Miterev et al. 2017 c; a) has been reviewed different organizational approaches suitable for PBO design. Most of them are focused in few organizational components, for instance human resources, strategy, or processes together with processes. According to this study, the holistic model design that widely encompasses PBO dimensions is Galbraith's Star-Model, composed of five components: strategy, processes, behaviour, human resource and structure. Moreover, the Star-Model has been adapted to the specific PBO concerns in (Miterev et al. 2017 a). Galbraith claims that the alignment is the most important characteristic of the Star-Model and each component of the organization – represented as a point of the star – should work to support the strategy (Galbraith 2007) as has also been shown through a recent analysis of the Star-Model as a network, where strategy is the central component and gives cohesion to the whole system (Atencio et al. 2022 b).

4. Results and Discussion

The following section follows the two steps structure presented in section 2.

4.2 Understanding the Models' Requirements

Based on the literature review developed in section 3, the following considerations are highlighted to be implemented in the model development:

- There are a set of PM ontologies with different focuses. However, the most cited ontology with a general approach suitable for integrating with an EA domain, such as PROMONT, is not available. Also, the presented articles which use PMBOK follow the sixth version. In order to provide an updated overview of the PM knowledge, a PMBOK 7th edition ontology based on a previous work of the authors available in (Atencio et al. n.d.) is used as a reference.
- Regarding the ontologies in EA, the identified works focus on specific domains. However, a general approach is needed to represent the EA domain in an abstract view. The ArchiMEO ontology covers a part of the intended goal of the proposed ontology and is available to be used. However, this model is not updated to the last version of ArchiMate (The 3.2 version), which includes the strategy, motivation, implementation & migration layers. These layers contain several concepts suitable to represent or align with PM concepts. Therefore, an updated ontology based on ArchiMEO and ArchiMate 3.2 is developed in this article as an EA reference.
- Concerning the PBO design concerns, the Star-Model presents a wide overview of an organization; the main requirement is the alignment of its components. With a preliminary analysis shows a correspondence between the Star-Model components (Strategy, structure, processes, rewards and people) and EA layers (Strategy, business, application, technology, physical, implementation & migration and motivation). The PM concepts required in a PBO, would appear in the proposed ontology through the PMBOK 7th concepts included.

4.2 Model development

The proposed ontology is developed following the METHONTOLOGY method and the following section is structured, responding to each of its seven steps.

(i) Specification

The model's purpose is to support PBO modelling, analysis and design. Moreover, this model is intended to be a management tool, enabling the interoperability of the PM concepts with the organization and its components.

(ii) Knowledge Acquisition

The knowledge acquisition has been performed through data extraction from the sources mentioned in the literature review section with a special focus on the ArchiMate 3.2 specification (Archi 2023), the ArchiMEO ontology (Hinkelmann et al. 2020) and PMBOK 7th edition (Edition 2021).

(iii) Conceptualization

The ontology model has been designed utilizing a top-down approach, which proves effective for application domains that are already well-established, with clearly defined levels of required detail and development scope. This approach accurately captures essential concepts and relationships within the domain, leading to a significantly enhanced and streamlined development process (Sandkuhl et al. 2015).

(iv) Integration

In order to reuse other ontologies useful for the proposed model, an ontology of PMBOK 7th edition was used as a PM reference, based on a previous work of the authors in (Atencio et al. n.d.). Regarding the EA domain, the ArchiMEO ontology was considered as a basis. This ontology has been updated to the ArchiMate version 3.2.

(v) Implementation

The proposed model was implemented in Protégé ontology editor by applying steps 3, 4 and 5 of METHONTOLOGY. Following the integration strategy described in section 3.2 (Bakhshandeh et al. 2013), the updated version of ArchiMate was merged with the PMBOK 7th ontology. Then, the PMBOK classes were analyzed in order to perform the alignment or mapping ontology activities to obtain an integrated model, as it is schematized in Figure 2.

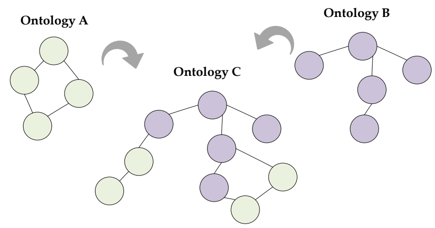

Figure 2. Schema of integration of ontologies

The correspondence analysis and the type of integration developed between PMBOK and ArchiMate ontology are provided in the Annexe. The resulting ontology is available in Protégé, as shown in Figure 3.

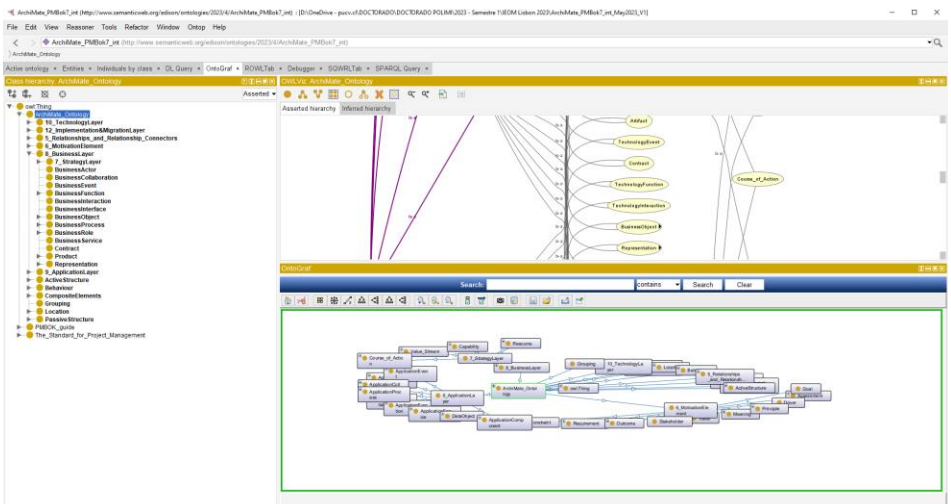

Figure 3. Integrated model in Protégé

(vi) Evaluation
The evaluation of the obtained ontology encompasses two activities (Fernández-López et al. 1997) (i) the verification, focused on the correctness of the ontology and the (ii) validation, in order to guarantee the correspondence between the model and the domain intended to represent. For this purpose and enterprise modelling, the SEQUAL framework [65] may complement the evaluation process. SEQUAL means syntactic, semantic and pragmatic evaluation. The correspondence between the METHONTOLOGY evaluation requirements and SEQUAL are displayed in Table 1, based on the evaluation analysis performed in (Atencio et al. n.d.).

Table 1. METHONTOLOGY evaluation and SEQUAL statements correspondence

METHONTOLOGY evaluation statement	**SEQUAL quality statement**	**SEQUAL question to assess the statement**
Verification	Physical quality	Is the model available for the relevant actors and not others?
Validation	Empirical quality	Is the model comprehensible?
Verification	Syntactic quality	Is the language correctly used in the model?
Validation	Semantic quality	Is there a correspondence between the model and the represented domain?
Validation	Perceived semantic quality	Is there a correspondence between the users' interpretation of the model and their domain knowledge?
Validation	Pragmatic quality	There is correspondence between the model and the actor's interpretation of it.
Validation	Social quality	Is there agreement among users' interpretations of the model?

The physical, syntactic and partial semantic quality evaluation will be performed in this research. Concerning the *physical quality*, the model is available for users. An analysis of *syntactic quality* was developed, assisted by the debugger tool available in Protégé. The debugging process was carried out using the Pellet incremental reasoner (Sirin et al. 2007). A reasoner[1] is a tool that enables reasoning tasks, mainly based on RDFS, OWL that supports identifying and repairing the inconsistency and incoherence of the ontology (Protégé 2023). After applying successive verifications along the modelling process, the report shows that the ontology is coherent and consistent, as presented in Figure 4.

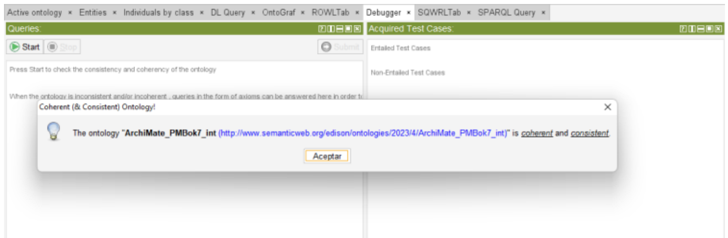

Figure 4. Debugger report using Pellet Incremental reasoner

Regarding the *semantic quality*, a set of statements are evaluated using the ontology.

Statement 1. There must be conformance between the ArchiMate structure and the ontology. From a top-level perspective, ArchiMate comprises layers and aspects, as shown in Figure 5.

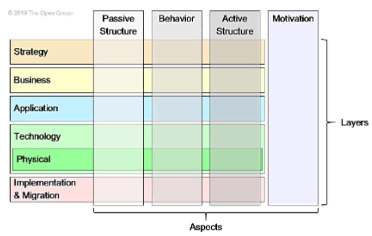

Figure 5. ArchiMate full framework

The composition displayed in Figure 5 can be observed in the developed ontology as shown in Figure 6.

Figure 6. ArchiMate layers and aspects in the ontology

Layers and aspects are interrelated. As evidence of this requirement, Figure 7 shows the classes related to the Active Structure of an EA.

[1] https://www.w3.org/2001/sw/wiki/Category:Reasoner

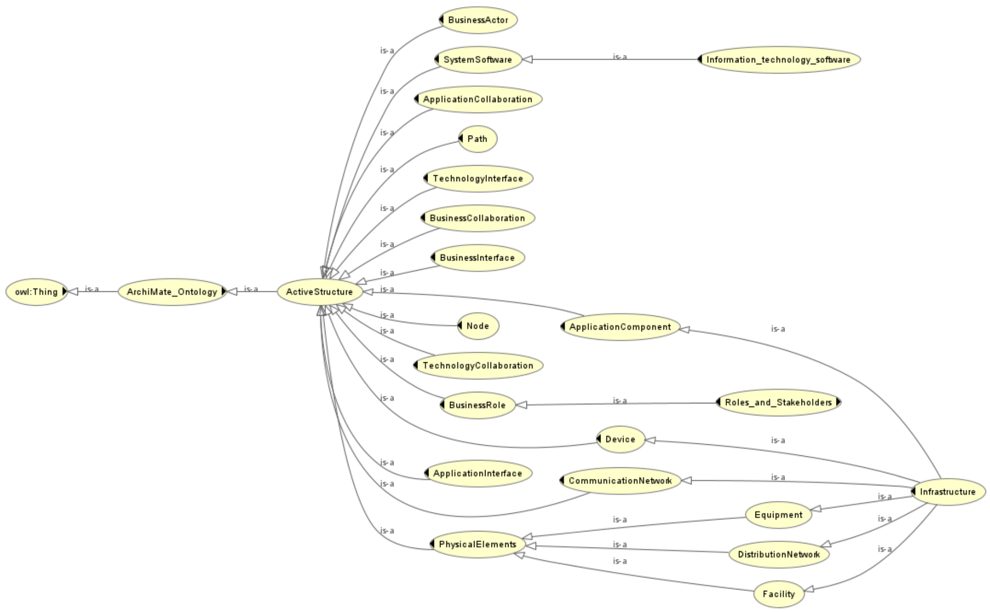

Figure 7. Composition of the Active Structure aspect of an EA

Figure 7 shows the `ApplicationComponent` class that is part of the `ApplicationLayer`. Then, ApplicationComponent is a subclass of the ActiveStructure and the Application Layer, as presented in Figure 8.

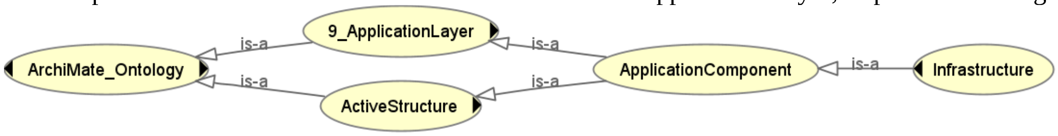

Figure 8. ApplicationComponent and its parent classes

Statement 2. ArchiMate and PMBOK 7th ontologies are integrated into a new ontology. Figure 8 shows how the project performance domains and the tailoring functions are part of PMBOK 7th and the BusinessFunction element, which is part of the `BusinessLayer` and the `Behaviour` aspect.

Figure 9. Project management functions in the integrated model

(vii) Documentation
The developed ontology is documented as a .RDF file available to be imported to Protégé. This file is available in the following link: https://drive.google.com/file/d/1fAQkEOzos3IygquUCTUHoiYfUEW7VVQj/view?usp=sharing

4.3 Proposed Improvements

The development model sets a first building block to provide an ontology encompassing PM knowledge and the EA components suitable for PBO modelling, analysis and design. However, the following steps to improve the ontology are related to the validation of the model. This article achieves only three of the seven quality requirements of SEQUAL framework for enterprise models. The pending validation must consider some activities performed with experts to assess the correspondence with the domain modelled and their interpretation. Moreover, ontologies development achieves a higher acceptance when implemented in real world through a case study, as seen in the work of (Jiang et al. 2022) and (del Mar Roldán-García et al. 2021). The first article develops a risk management ontology applied to construction projects. The second work develops an ontology-driven key performance indicators (KPI) system and tests the ontology in a water engineering management projects case study.

A case study to test the developed ontology may consider modelling a real PBO by establishing individuals, which are *instances*[2] of a set of classes of different model components, such as `BusinessProcess`, `Project` or `People`. Moreover, data properties may be defined together with the individuals.

The main requirement of the ontology is to provide a tool for the PBO analysis. As presented in section 3.1, one of the benefits of using ontologies is *(x) Managing complex logical axioms through machine-readable models.* Then a set of questions can be answered using the ontology through the Semantic Web Rule Language (SWRL[3]) tool for querying the ontology. An SWRL tab is available in Protégé.

The following query example may be performed through the proposed ontology:

What outcomes are expected from the PBO EA provided by the whole WorkPackages? This question crosses the ArchiMate and PMBOK ontology together because, to develop a query, the atoms consider an ArchiMate class and the expected result is an individual of a PMBOK class. As shown in Figure 10, the class `Project` has the instance `EIC_digital_transformation` as a specific project. This project `Produces` three outcomes.

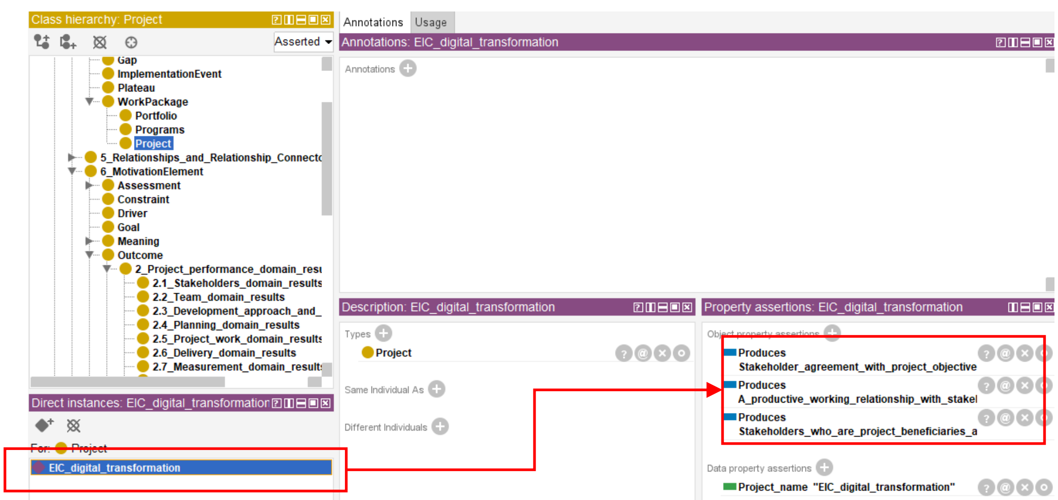

Figure 10. Project class instance and the outcomes expected to be produced

Each `Outcome` is an instance of the `2_Project_performance_domain_results` class as part of the `6_MotivationElement` class and an EA aspect, as shown in Figure 11.

[2] a concrete object derived from a class (https://wikieducator.org/Ontology

[3] https://www.w3.org/Submission/SWRL/

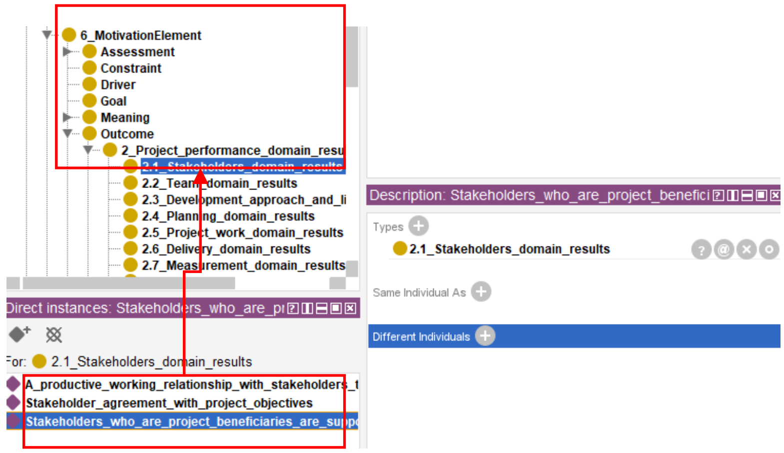

Figure 11. Outcomes individuals associated with the EA

Performing a query may be a useful tool when the complexity of the modelled PBO makes it difficult to answer the question through graphical analysis. Then, the following query allows quickly obtain the expected answer (Figure 12):

```
WorkPackage(?p) ^ Produces(?p, ?r) -> sqwrl:select(?p, ?r)
```

Answer:

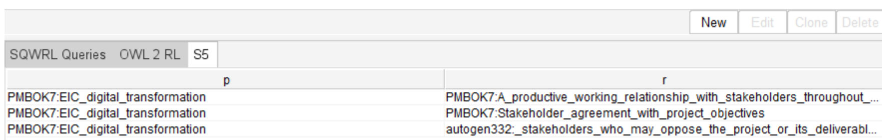

Figure 12. Answer obtained from an SWRL query

Therefore, using the SWRL tool available in Protégé, the benefits are twofold. On the one hand, this tool allows perform validation to verify the content and relationship of the modelled domain regarding the experts' requirements. On the other hand, in a case study, querying may be a powerful tool for understanding the composition of the PBO and discovering implicit relationships enabling business rules.

6. Conclusion

An integrated model between PM and EA has been developed in this paper in order to provide alternative tool management for PBO modelling, analysis and design. This tool is based on widely accepted PM and EA reference frameworks: PMBOK and ArchiMate. Moreover, this work provides an updated overview of the ArchiMate ontology considering that, as the main reference in the literature, ArchiMEO do not consider a set of components required to model the PM knowledge. Then, this paper provides a complete ontological model of ArchiMate.

A preliminary evaluation has been carried out on the proposed model. However, to achieve a higher level of acceptance of this ontology, a set of models' quality requirements must be performed with experts. Moreover, a case study may help assess this model's usability in the real world.

The analysis performed for each concept of PM and EA and the model development shows that ArchiMate as an EA language can cover all aspects of PM. The above shows the potential of the EA as a management tool in the PM field and for the PBO representation. This work encourages researchers to evaluate the EA approach as a governance tool for managing projects and their complexity.

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