A Conceptual Model for Describing and Classifying Interoperability Types - Extended Abstract – CTDGSI 2025

Kécia Souza Santana Santos[1]**, Pedro Henrique Valle**[2]**, Rita Suzana Pitangueira Maciel**[1]

[1]Federal University of Bahia (UFBA)
Av. Adhemar de Barros, s/n, Ondina – Salvador – BA – Brazil

[2]University of São Paulo (USP)
Rua do Matão, 1010 - Butantã – São Paulo – SP – Brazil

kecia.souza@ufba.br, pedrohenriquevalle@usp.br, rita.suzana@ufba.br

Abstract. *Interoperability is critical to modern information systems, enabling collaboration and data exchange across different software and domains. This master's thesis reviews 37 secondary studies (2012–2023), identifying 36 types of interoperability, 117 definitions, 13 models, and six frameworks, highlighting a shift from technical to socio-technical issues. To address challenges related to this requirement fulliment, a conceptual model with two diagrams was proposed and evaluated, achieving 87.9% acceptance for the classification diagram and 78.8% for the description diagram. The research aims to improve the understanding of interoperability requirements and contribute to the challenges of the GrandSI-BR 2016–2026 roadmap.*

1. Introduction

Interoperability allows systems to exchange and use shared information without technological dependency. It is essential for complex systems to ensure transparent communication. Interoperability types include `syntactic` , `semantic`, `legal`, `platform` among others. The growing number of types leads to ambiguity, complicating developers' understanding and system development [Maciel et al. 2024]. Interoperability is a crucial non-functional requirement, and precise definitions are essential to avoid project losses. Models like LCIM (Levels of Conceptual Interoperability Model) and EIF (European Interoperability Framework) aid in classification. However, they do not address several current interoperability types. Studies have organized knowledge in the field [Fernandes et al. 2022, Costa et al. 2022]. Despite these contributions, more precise definitions and classifications are needed to enhance cooperation among information systems.

This master dissertation proposes a conceptual model to assist software developers in interoperability solutions. The research followed five stages: **Step 1:** Identification of new Interoperability Types [Santos et al. 2021]; **Step 2:** Identification of barriers or differences; **Step 3:** Understanding solutions; **Step 4:** Developing a conceptual model; **Step 5:** Evaluation of conceptual model. All the materials produced in this dissertation are available at [Maciel et al. 2025] .

2. A Conceptual Model for the Diversity of Interoperability Types

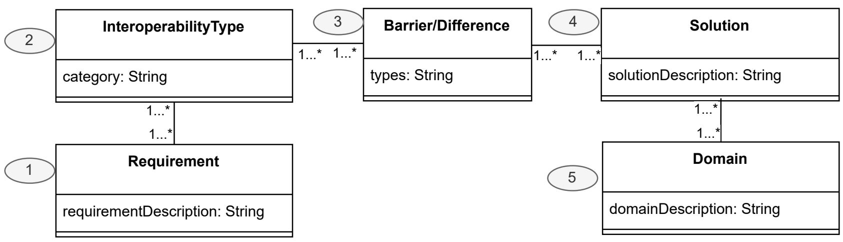
This conceptual model includes two UML class diagrams: one for describing fundamental concepts and another for classifying various types identified in the literature.

.

The classification diagram includes three abstract classes, five concrete classes, and six enumerations. It groups similar interoperability types and links classification and description diagrams. The *Interoperability Type* abstract class contains *definition* and *understanding* attributes. Other classes define characteristics and levels of interoperability types.

The description diagram [Maciel et al. 2025] includes five classes: Requirement, Interoperability Type, Barrier/Difference, Solution, and Domain. These classes specify system functionality, categorize interoperability types, represent challenges, address system heterogeneity, and outline application domains.

The conceptual model should be instantiated from two perspectives: classifying and defining interoperability types . The description diagram 1 links system requirements to specific interoperability types, aiding developers in identifying the needed type and solution. The classification diagram [Maciel et al. 2025] had a 92.6% acceptance rate, and the description diagram had an 81.5% acceptance rate. This research enhances understanding and use of interoperability requirement specifications, contributing to full interoperability and Systems-of-Systems Interoperability (SOSI).



Interoperability Description		
Requirement		
Two distincts EHR (Eletronic Health Record) Systems need to share pacient information, beside using different vocabulary.		
Interoperability Type	Semantic	
Barrier or Difference	Barrier	
Solution	Ontologies	
Domain	Health	

Figure 1. Instantiation of interoperability types description

3. Conceptual Model Evaluation

The proposed conceptual model was evaluated through an exploratory study of 33 software developers. The goal is to assess the model's feasibility and ease of use. The study addresses the following research questions: **RQ**$_1$: Would developers use the conceptual model in their projects? **RQ**$_{1.1}$: Is the conceptual model easy to use? **RQ**$_{1.2}$: What difficulties have developers faced when using the conceptual model? **RQ**$_2$: Is the conceptual model feasible for dealing with the diversity of interoperability types? The target audience consists of software developers recruited via LinkedIn. The study employs two questionnaires: the **first** focuses on demographic information, while the **second** assesses feasibility and ease of use [Maciel et al. 2025]. Moreover, to ensure confidentiality, participants provided explicit consent. A pilot study was conducted beforehand to verify and refine the questionnaires. The regular study then proceeded in three phases, each evaluating different aspects of the model. Finally, data analysis combined quantitative and qualitative approaches, following the guidelines established by [Freitas et al. 2000].

The assessment of the conceptual model for interoperability included 33 complete responses out of 44 software developers who participated. Notably, most developers expressed willingness to adopt the model, finding it easy to use. However, some challenges were also reported. As expected, less common types—such as *hardware*, *semantic*, *organizational*, *cultural*, and *social networks*—revealed varying levels of understanding among participants. Overall, the findings suggest that the model enhances developers' comprehension of interoperability types. The complete responses are available at [Maciel et al. 2025].

4. Conclusion

This work introduced a conceptual model for classifying and describing interoperability types, synthesizing 36 types, 117 definitions, 13 models, and six frameworks. It aids developers and researchers by reducing ambiguities and promoting context-specific solutions. The well-received model advances Full Interoperability and Systems-of-Systems Interoperability (SOSI). Future work could extend and validate the model in real projects.

References

Costa, M. G. N., Paiva, D. M. B., and Cagnin, M. I. (2022). How are the interoperability requirements addressed in the systems-of-systems context? In *Proceedings of the XVIII Brazilian Symposium on Information Systems*, SBSI '22, New York, NY, USA. Association for Computing Machinery.

Fernandes, J., Cordeiro, F., Ferreira, F., Neto, V. V. G., and dos Santos, R. P. (2022). A method for identification of potential interoperability links between information systems towards system-of-information systems. *iSys-Brazilian Journal of Information Systems*, 15(1):2–1.

Freitas, H., Oliveira, M., Saccol, A. Z., and Moscarola, J. (2000). O método de pesquisa survey. *Revista de Administração da Universidade de São Paulo*, 35(3).

Maciel, R. S., Valle, P. H., and Santos, K. S. (2025). Available materials. `https://docs.google.com/document/d/1QsckBAsS-SDYL9A1Kbt1t0qRbVGZ_kXxeSHAD6R6pEs/edit?usp=sharing`.

Maciel, R. S., Valle, P. H., Santos, K. S., and Nakagawa, E. Y. (2024). Systems interoperability types: A tertiary study. *ACM Computing Surveys*.

Santos, K. S. S., Pinheiro, L. B. L., and Maciel, R. S. P. (2021). Interoperability types classifications: A tertiary study. In *XVII Brazilian Symposium on Information Systems*, pages 1–8.