

Contours of Knowledge: Epistemological Implications of Semantic Models in the Representation of the Art Exhibition Domain through the Lens of the OntoExhibit Ontology



Obrisi znanja: epistemološke
implikacije semantičkih
modela u prikazu domene
umjetničkih izložbi kroz
prizmu ontologije OntoExhibit

IZVORNI ZNANSTVENI RAD
Primljen: 28. veljače 2024.
Prihvaćen: 10. rujna 2024.
DOI: <https://doi.org/10.31664/zu.2024.114.06>

ORIGINAL SCIENTIFIC PAPER
Received: February 28, 2024
Accepted: September 10, 2024
DOI: <https://doi.org/10.31664/zu.2024.114.06>

SAŽETAK

Članak se bavi epistemološkim utjecajima semantičkih web-modela u kulturnom polju, s naglaskom na ontologiju OntoExhibit. Semantičke web-tehnologije imaju potencijal znatno unaprijediti upravljanje kulturnim sadržajem te njegovo širenje, istraživanje i razumijevanje u kulturnom sektoru. Njihova primjena u području kulture obilježila je transformativan pomak prema povezanijem i pristupačnijem digitalnom kulturnom krajoliku putem koncepata povezanih podataka i otvorenih povezanih podataka. Primjerice, povezivanjem podataka iz različitih muzeja, knjižnica i arhiva, semantički web može izraditi sveobuhvatne digitalne zapise kulturnih artefakata, omogućujući kombiniranje i analiziranje informacija iz različitih izvora. Kako bi se postigao cilj razvoja smislene strukturirane podatkovne mreže u kojoj se podaci mogu međusobno povezivati, semantički web odlikuje se strukturiranim pristupom koji obuhvaća formalizaciju znanja, modeliranje domena i klasifikaciju podataka. Ovaj se članak bavi izazovima i konceptualnim složenostima svojstvenima predstavljanju, formalizaciji i modeliranju složenih kulturnih ekosustava, poput domene umjetničkih izložbi. Također, poziva na kritičko preispitivanje ograničenja i pretpostavki ugrađenih u uspostavljene referentne modele koji se primjenjuju u projektima semantičkog weba, posebno CIDOC-CRM, kako bi se postiglo sveobuhvatno razumijevanje prikaza iz područja kulture. Preispitivanje je provedeno na primjeru konceptualnih i epistemoloških izazova koji su se pojavili pri razvoju modela OntoExhibit.

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ABSTRACT

This paper delves into the epistemological impacts of deploying semantic web models within the cultural field, especially through the lens of the OntoExhibit ontology's approach to modeling art exhibition ecosystems. It highlights OntoExhibit's engagement with the socio-discursive practices and productions, the semantic and symbolic layers they generate, and the materiality of the art exhibition phenomenon, advocating for a nuanced reevaluation of materiality and agency in the context of the semantic models' development. The article addresses the epistemological challenges and conceptual intricacies inherent in representing complex cultural ecosystems, underlining the imperative to critically examine the constraints and assumptions embedded in existent reference models, with a particular focus on CIDOC-CRM as the prevalent standard in cultural representation and documentation. The article suggests the need for a renovated and broader perspective that encompasses the evolving requirements of the formal representation of the cultural field in the AI era.

KEYWORDS

ontologies, semantic web, art exhibitions, complex cultural ecosystems, CIDOC-CRM, knowledge representation

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Model OntoExhibit osmišljen je kako bi omogućio predstavlanje, objavljivanje, pristup i ponovnu upotrebu semantički obogaćenih informacija povezanih s umjetničkim izložbama. Ta ontologija proširuje konceptualni model koji stoji iza alata Expofinder, relacijske baze podataka razvijene u okviru projekta *Exhibitium*. OntoExhibit pristupa području umjetničkih izložbi kao složenom kulturnom ekosustavu, sastavljenom od heterogenih aktera (ljudskih i neljudskih) koji sudjeluju u diskurzivnim i društvenim praksama utjelovljenima u materijalnim odnosima. To rezultira stvaranjem bogatog mozaika značenja i simboličkih vrijednosti. Posljedično, primarna razlika između modela OntoExhibit i drugih prijedloga za modeliranje umjetničkih izložbi leži u njegovu posebnom naglasku na sociodiskurzivne produkcije i prakse, semantičke i simboličke slojeve koji iz njih proizlaze te na materijalnost fenomena umjetničkih izložbi. U skladu s tim, OntoExhibit potiče preispitivanje pojmova materijalnosti i djelovanja (engl. *agency*) unutar semantičkih modela te naglašava nužnost usvajanja kombiniranog materijalističkog i posthumanističkog pristupa u eri predvođenoj umjetnom inteligencijom.

Kako bi postigao taj cilj, model OntoExhibit uvodi različite klase. Prvo, slijedeći glavnu shemu FRBRoo-a, uspostavljena je distinkcija i međusobna povezanost između konceptualnih konstrukata koje nazivamo „djelo” i specifičnih materijalnih realizacija tog djela, koje nazivamo „manifestacija”. U skladu s tim, OntoExhibit razlikuje „izložbeno-kustoski projekt” (klasificiran kao podrazred „konceptualnog djela”), koji se definira kao intelektualna konceptualizacija izložbe, i samu klasu „izložbe” (podrazred „manifestacije djela”). Takav pristup omogućuje nijansirana ispitivanja redefinicija kustosko-izložbenih projekata kroz različite materijalizacije, čime se podupire istraživanje raznih interpretacija i diskurzivnih evolucija. Na primjer, OntoExhibit znatno unapređuje predstavljanje putujućih izložbi i suvremenih ponovljenih izdanja povijesnih izložbi. Svaku izložbu u nizu vidi kao jedinstvenu materijalizaciju ili manifestaciju, omogućujući prilagodbe specifične za određene prostore i promjene kustoskog narativa, no povezane zajedničkim izložbeno-kustoskim projektom.

Drugo, uvođenje novih klasa poput „propozicije” (čisto konceptualni entiteti) i „propozicijskog objekta” (materijalni entiteti koji prenose propozicije) omogućuje predstavljanje širokog spektra diskurzivnih praksi i produkcija nastalih oko izložbi, uključujući recenzije, brošure, kataloge, eseje, interakcije na društvenim mrežama i djela prikazana na izložbama. Uvođenje tih klasa predstavlja važno epistemološko pitanje, naglašavajući neraskidivu vezu između materijalnosti i propozicije, posebno kroz klasu „propozicijski objekt”, koja je jasno definirana kao materijalni objekt prožet semantičkim sadržajem. Ta definicija razjašnjava nejasnoće prisutne u klasi CIDOC-CRM. Klasa „dodjela propozicije” omogućuje detaljnu analizu propozicija koje izložbe dodjeljuju entitetima unutar ekosustava, poput umjetničkih djela i eseja, kao i obratno.

OntoExhibit uključuje i postantropocentričku perspektivu, priznajući djelovanje neljudskih entiteta u kreativnim i kustoskim procesima. Uvodi klase za neljudske aktante, kao što su biološke vrste, i tehnoktante, kao što su sustavi umjetne inteligencije, čime se odražava dinamična interakcija između ljudske i neljudske kreativnosti u izložbama suvremene umjetnosti. Takav pristup propituje tradicionalne klasifikacije koje ograničavaju djelovanje na ljudske aktere i uzima u obzir sve veću ulogu umjetne inteligencije i drugih tehnologija u domeni kulture.

Model također predlaže šire razumijevanje „materijalnih objekata” kao entiteta koji se manifestiraju na digitalnoj ili fizičkoj razini realizacije. Takva šira definicija propituje redukcionistički pogled koji izjednačuje materijalnost s fizikalnošću, a prisutan je u hijerarhiji CIDOC-CRM, priznavanjem opipljivog utjecaja i prisutnosti digitalnih i računalnih objekata. Slično tome, spajanjem materijalnog sa semantičkim/simboličkim sadržajem u klasi „propozicijski objekt”, OntoExhibit nadilazi raskol između konceptualnih i materijalnih objekata, zagovarajući šire razumijevanje materijalnosti u digitalnom dobu.

Članak se zaključuje naglašavanjem ključne uloge ontologije u suočavanju s epistemološkim izazovima u digitalnoj eri.

KLJUČNE RIJEČI

ontologija, semantički *web*, umjetničke izložbe, složeni kulturni ekosustavi, CIDOC-CRM, predstavljanje znanja

INTRODUCTION

Over the past decade, semantic web technologies have gained significant prominence in the cultural field due to their capacity to enhance the management, dissemination, exploration, and understanding of cultural content. This has resulted in a transformative shift toward a more connected and accessible digital cultural landscape. The semantic web represents an extension of the current web, designed to enable machines to understand and interpret the data on the web in a more intelligent and interconnected manner. In contrast to the conventional web, which is principally designed for human consumption, the semantic web aims to create a more structured and expressive data ecosystem that can be used effectively by both humans and machines.¹ The primary objective of the semantic web is to link data from different sources, thereby facilitating the connection of disparate pieces of information in meaningful ways. This is the foundation of what is known as Linked Data. To achieve this objective, semantic web technologies comprise a framework of standardized formats and languages, such as RDF (Resource Description Framework)² and OWL (Web Ontology Language),³ which are used to encode data in a way that machines can process, thereby enabling large-scale data integration.

The semantic web holds significant potential in the cultural sector, offering numerous applications that can enhance the management, accessibility, interpretation, and preservation of cultural heritage.⁴ For example, by linking data from different museums, libraries, and archives, the semantic web can facilitate the creation of comprehensive digital records of cultural artifacts. Similarly, as semantic web technologies enrich data with contextual information, this enables a more nuanced understanding of context and relationships between data, providing more precise and relevant search results and, therefore, allowing users to find relevant information more efficiently. Thus, semantic web technologies can improve the discoverability and accessibility of cultural content. Along with fostering collaboration between institutions through standardized data formats, semantic web technologies facilitate the preservation of cultural heritage and open new avenues for data-driven research, allowing scholars to explore vast datasets for insights.⁵

The semantic web is characterized by a structured approach that encompasses knowledge formalization, domain modeling, and the classification of data. This approach is essential for achieving the objective of building a meaningful structured data web where data can be interconnected. Knowledge formalization and domain modeling are the processes of creating a conceptual model that represents, in a formal manner, the structure, behaviors, and constraints of a specific domain or area of interest. This process entails the identification and definition of the principal entities, their attributes, relationships, and interactions within the domain. In the field of the semantic web, these intellectual tasks are articulated around the notion of ontology, which can be

¹ Berners-Lee et al, "Semantic Web," 34–43.

² RDF is a data format designed to represent information on the Web. It enables a standardized framework that facilitates information sharing between applications while preserving the data's meaning. RDF uses URIs (Uniform Resource Identifiers) to identify resources, structuring them into triples comprising a subject, predicate, and object. According to W3C recommendations, RDF is best utilized in scenarios where data needs to be processed by various applications rather than merely being presented to users.

³ OWL (Web Ontology Language) is a computational logic-based designed to represent rich and complex knowledge.

⁴ *Linking Knowledge. Linked Open Data for Knowledge Organization and Visualization* (Smiraglia and Scharnhorst, 2021) and the special issue on Cultural Heritage and Semantic Web of the *Semantic Web Journal* (vol. 14, n. 2, 2023) offer comprehensive reviews of current research directions in Semantic Web and linked open data within this field.

⁵ Lodi et al., "Semantic Web for Cultural Heritage Valorisation," 3–37.

defined as a formal description of knowledge comprising a set of concepts and the relationships among them.⁶ See Fig. 1 for an illustration, which represents the simplified conceptual model underlying the OntoExhibit ontology. The fundamental components of an ontology are classes (or concepts), relations (or properties), and instances (or individuals). An ontology data model may be populated with a collection of individuals using a knowledge graph, which is defined as an interconnected set of entities. In a knowledge graph, nodes represent entities (either things or concepts), and edges represent the semantic relationships these entities. Ontologies, thus, provide a shared conceptualization and vocabulary for a domain, defining the meaning of terms and the relationships between them, thereby enabling interoperability between systems. Consequently, at the core of Semantic Web technologies lies an important work of conceptual modeling and epistemological inquiry. In other words, the development of the Semantic Web involves a process of epistemological redefinition and reformulation of the domains of reality. In the cultural domain, these epistemological complexities have been approached from different angles. Thus, the multiplicity of interpretations associated with cultural objects and phenomena,⁷ the representation of ambiguous temporalities,⁸ the interpretation of artworks' subject matter, or the encoding of values and arguments conveyed by art criticism,¹⁰ among others, have been addressed within diverse research initiatives.

This article aims to contribute to this body of research by focusing on the epistemological issues inherent in the modeling process underlying ontology development. In particular, it addresses the conceptual and epistemological challenges encountered in developing the model that is the basis of OntoExhibit,¹¹ a formal ontology built with OWL2 to represent, model, and formalize the art exhibition domain. OntoExhibit is one of the outstanding results of a research program that has been underway since 2015, consisting of three research projects: the *Exhibitium Project* (2015–2016),¹² the *Andalex Project* (2017–2022),¹³ and the *Complexhibit Project* (2022–2025).¹⁴ The common goal of all these projects has been the development of analytical strategies, methodologies and technological tools aimed at expanding the knowledge of the art exhibition domain.

The modeling of OntoExhibit has triggered central epistemological discussions about the conceptualization of the art exhibition domain, as well as critical debates within the research team about existing reference models, in particular the CIDOC-CRM,¹⁵ which has become the standard reference model in the cultural field. These reference models naturally contain certain underlying assumptions about knowledge and interpretations of the formalized cultural domain that need to be carefully considered. Consequently, the discussions around OntoExhibit have underscored the challenges of accurately representing the complex nature of the art exhibition domain while also highlighting the need to examine the epistemological assumptions, conceptualizations and interpretations embedded in reference models.

6 Gruber, "A translation approach to portable ontology specifications," 199–220.
 7 Van Ruymbekke et al., "Implementation of Multiple Interpretation," 50–65.
 8 Van den Heuvel, Zamborlini, "Modeling and Visualizing Storylines," 99–141.
 9 Bruno et al., "ICON: An Ontology for a Comprehensive Artistic Interpretation," 1–38.
 10 Mancini, Sauro, "A Conceptual Model for Art Criticism," 138–157.
 11 Rodríguez-Ortega et al., *OntoExhibit*.
 12 See the *Exhibitium Project* website.
 13 See the *Andalex Project* website.
 14 See the *Complexhibit Project* website.
 15 The CIDOC Conceptual Reference Model (CIDOC-CRM) is a comprehensive ontological framework designed to facilitate the integration, mediation, and interchange of heterogeneous cultural heritage information. Developed by the International Committee for Documentation (CIDOC) of the International Council of Museums (ICOM), CIDOC-CRM serves as a formal structure aimed at describing concepts and relationships used in cultural heritage documentation. See the CIDOC-CRM website.

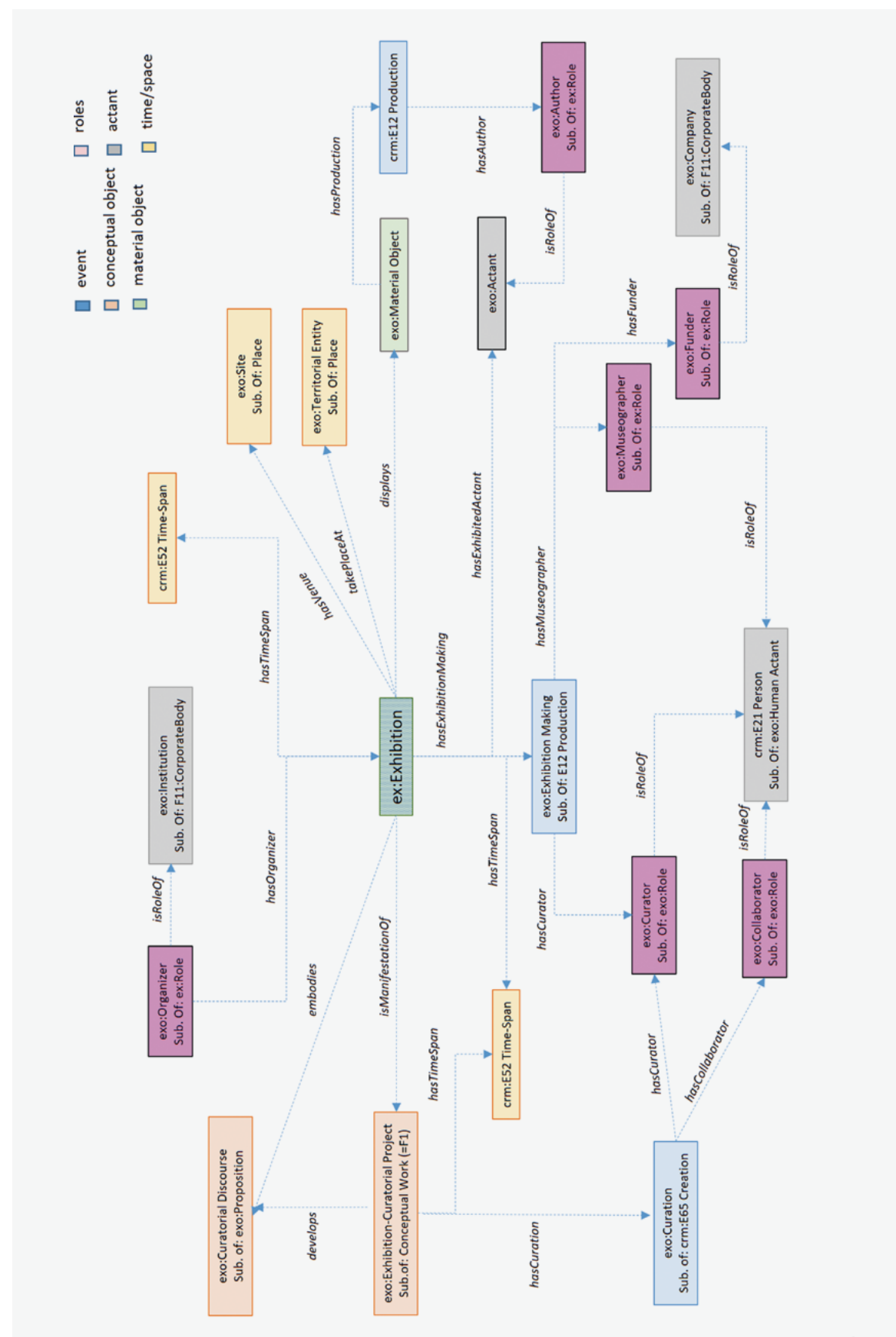


Fig. / Sl. 1 A simplified representation of the main components of OntoExhibit's conceptual model. / Pojednostavnjeni prikaz glavnih komponenti konceptualnog modela OntoExhibit.

This is not trivial, given that these assumptions, conceptualizations, and interpretations are inherited by all subsequent models derived from them. Therefore, such an exploration is crucial to understanding of how cultural domains are represented and conceptualized in the context of an evolving digital culture. Likewise, these debates have highlighted the role of ontology as a case study in the broader conversation about the epistemological complexities inherent in our digital age. Thus, the purpose of this article is not to delve into a comprehensive modeling of the exhibition domain provided by the OntoExhibit framework but rather to examine some of the epistemological dilemmas and considerations that have shaped its development. It is also important to note that this is version 1.0, with plans for further expansion and refinement.

ONTOEXHIBIT: AN ONTOLOGY FOR THE
 ART EXHIBITION DOMAIN
 AS A COMPLEX CULTURAL ECOSYSTEM

OntoExhibit (version 1.0) is an ontology designed to enable the representation, publication, consumption, access, and reuse of semantically enriched encoded information related to the art exhibition domain. OntoExhibit is primarily a response to the need for mechanisms that align such information with the FAIR principles—findability, accessibility, interoperability, and reusability—which are essential for ensuring standardization, harmonization, interoperability, reusability, and discoverability.¹⁶ OntoExhibit thus aims to contribute to these goals, commonly associated with formal ontologies, such as data aggregation, enrichment, search, exploration, knowledge extraction, as well as providing modeling solutions to represent complex cultural ecosystems.

OntoExhibit is the result of transforming and extending the conceptual model underlying Expofinder, a relational database developed within the *Exhibitium Project*.¹⁷ The Expofinder model responds to the traditional concept associated with the exhibition field, which may be defined as a network made up of the relationships established between different actors (artists, curators, institutions) and cultural objects through exhibitions (Fig. 2). This model has served as the foundation for the design and construction of the OntoExhibit model, which represents an expanded version that stems from a refined conceptualization of the exhibition field. This conceptualization was informed by extensive conversations with a diverse community of researchers, curators, gallery owners, and art critics.

The approach proposed by OntoExhibit is driven by the necessity to adopt a combined materialist and post-humanist perspective, which is crucial in an era marked by advanced technology and the pervasive influence of AI on creative and knowledge production processes. OntoExhibit regards the art exhibition field as a complex cultural ecosystem comprising heterogeneous actors, both human and non-human,

¹⁶ Wilkinson et al., "The FAIR Guiding Principles for scientific data management and stewardship."

¹⁷ Rodríguez-Ortega, Cruces-Rodríguez, "Development of Technological Ecosystems," 423–448.

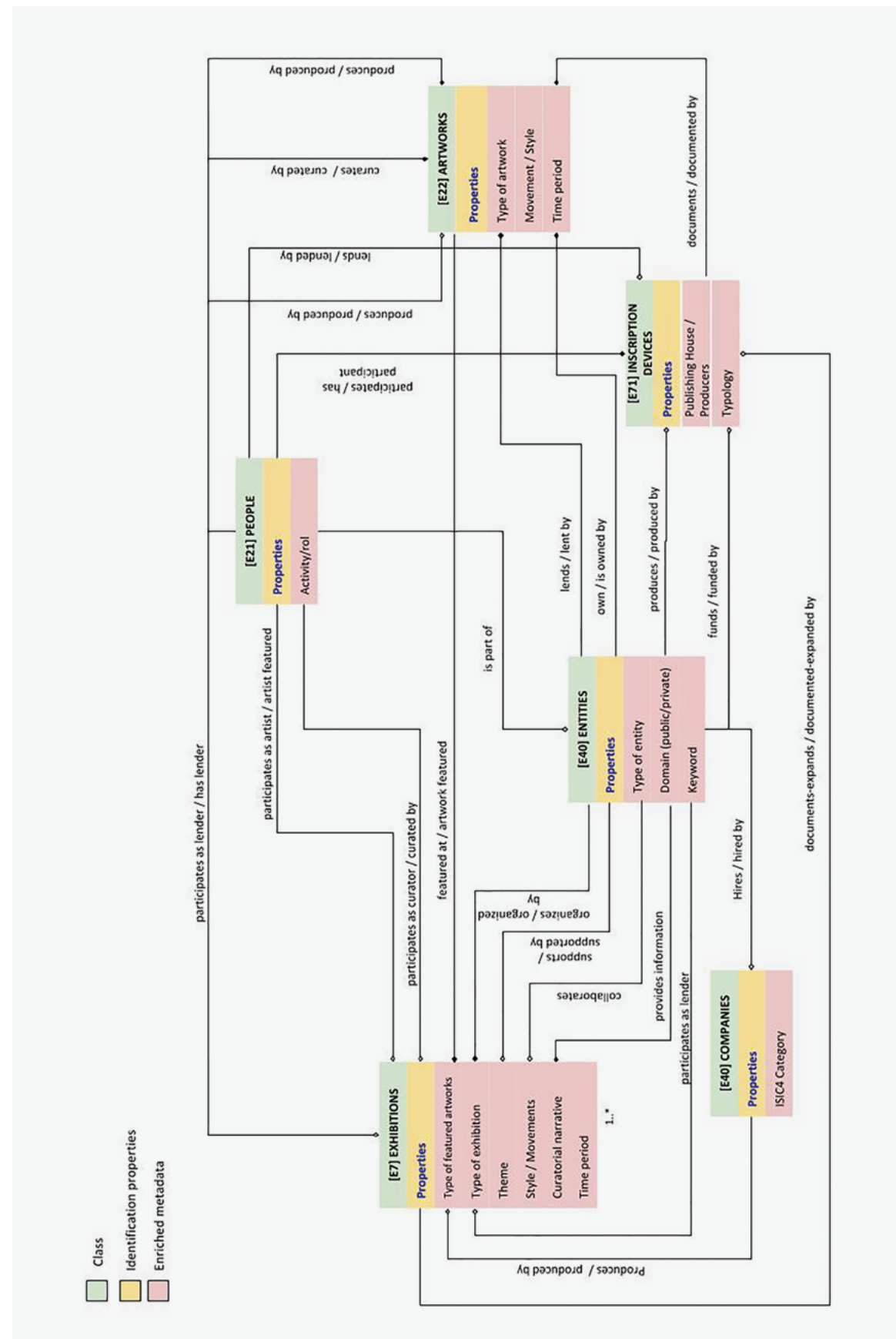


Fig. / Sl. 2 A simplified representation of the Expofinder model, 2016. Authors: Nuria Rodríguez-Ortega and Antonio Cruces-Rodríguez. / Pojednostavnjeni prikaz modela Expofinder, 2016. Autori: Nuria Rodríguez-Ortega i Antonio Cruces-Rodríguez.

engaged in an entanglement of discursive and social practices embodied in material relationships. This results in the creation of a rich tapestry of meanings and symbolic values. In this light, OntoExhibit addresses the art exhibition as a dual phenomenon: firstly, as a distinct discursive, social, and cultural production emerging from a network of material practices and interactions, and secondly, as a producer/generator of discourses and public spheres. These public spheres are, in turn, shaped by discursive and social practices that also convey meanings and generate symbolic value, which can influence subsequent exhibitions and create a continuous cycle of impact and significance. According to this conceptualization, the overarching goal of OntoExhibit is to enhance our comprehension of the structures, networks, and behavioral logics of this cultural ecosystem, as well as our understanding of its social, discursive and semantic intricacies. Consequently, OntoExhibit has been designed to represent this complexity and illuminate how these dimensions, practices, and productions intersect in the generation and dissemination of meanings, ideas, concepts, and symbolic values. To achieve this objective, OntoExhibit integrates conventional modeling approaches of the art exhibition domain with novel extensions.

As previously stated, the modeling of OntoExhibit has prompted significant epistemological discussions, particularly regarding its alignment with reference ontologies such as CIDOC-CRM (7.2.1.) and FRBRoo (3.0).¹⁸ Indeed, the distinct approach encapsulated in the OntoExhibit model is partly born out of the conceptual and epistemological conflict with these models. These discussions will be further elucidated in the subsequent sections.

Despite the growing relevance of the art exhibitions field across various contexts—including art historical research, where there has been a notable increase in data-driven projects, museum activities, curatorial practices, and the cultural and creative industries (CCIs)—the development of formal ontologies for publishing data as Linked Open Data (LOD) has been limited. To date, only a few initiatives have proposed models that partially integrate the art exhibition field, such as Prado's Digital Semantic Model¹⁹ or the Linked Art project.²⁰ With regard to projects based on exhibition data repositories, the recent initiative of the Artl@S project, which has transformed its BasArt database into an ontological model, stands out as a notable and singular effort.²¹ These are, for the most part, very recent developments built as CIDOC-CRM specifications.

The primary distinction between OntoExhibit and the aforementioned proposals is that OntoExhibit places a particular emphasis on socio-discursive practices, along with the semantic and symbolic layers that emerge from them. This approach differs from other proposals, which lack this focus. The subsequent sections will elaborate on this differentiated approach. What should be emphasized at this point, however, is that, despite the advent of these initiatives, a comprehensive debate about the limitations and

inadequacies inherent in the epistemological assumptions of the reference models is still needed. This circumstance is not trivial when we consider that, as noted above, to the extent that these proposals take CIDOC-CRM as their basis, they inevitably inherit such limitations and inadequacies, as discussed in the following sections.²²

MODELING THE SEMANTIC-DISCURSIVE DIMENSION OF ART EXHIBITION ECOSYSTEMS

Redefining the general epistemological framework

The OntoExhibit model has been enriched primarily through the introduction of distinct classes designed to facilitate the comprehensive integration of both the wide array of discursive practices and productions generated around exhibitions—including newspaper and magazine reviews, ephemeral documents, brochures, websites, catalogs, academic essays, social media interactions, visual and audiovisual contents, curatorial texts, and exhibition-making materials²³—and the propositional content—comprising theses, arguments, hypotheses, interpretations, critical discussions, concepts, aesthetic evaluations, and so forth—conveyed and embodied by these discursive formats and practices. This modeling is based on two central operations (Fig. 3).

¹⁸ FRBRoo (Functional Requirements for Bibliographic Records—Object Oriented) is an ontological extension of the CIDOC Conceptual Reference Model (CIDOC-CRM) specifically designed to represent bibliographic information and relationships according to the FRBR (Functional Requirements for Bibliographic Records) framework. Developed through a collaboration between the International Working Group on FRBR and CIDOC, FRBRoo aims to provide a formal structure for integrating and managing bibliographic and museum information. See the FRBRoo website.

¹⁹ See the Museo del Prado Semantic Model website.

²⁰ See the Linked Art website.

²¹ Carboni, Usel, Joyeux-Prunel, "Intégrer des données historiques spatio-temporelles."

²² However, there are a few cases in recent research that also postulate a critical view of CIDOC-CRM from an ontological point of view and present alternative forms of alignment. See, for example, Bruno et al., "ICON: An Ontology for a Comprehensive Artistic Interpretation," 1–38; Lodi et al., "Semantic Web for Cultural Heritage Valorisation," 3–37; Wijesundara et al., "A Metadata Model to Organize Cultural Heritage Resources," 81–94.

²³ They are all examples of inscription devices that allow us to identify and analyze the set of social and discursive practices that take place around the exhibitions.

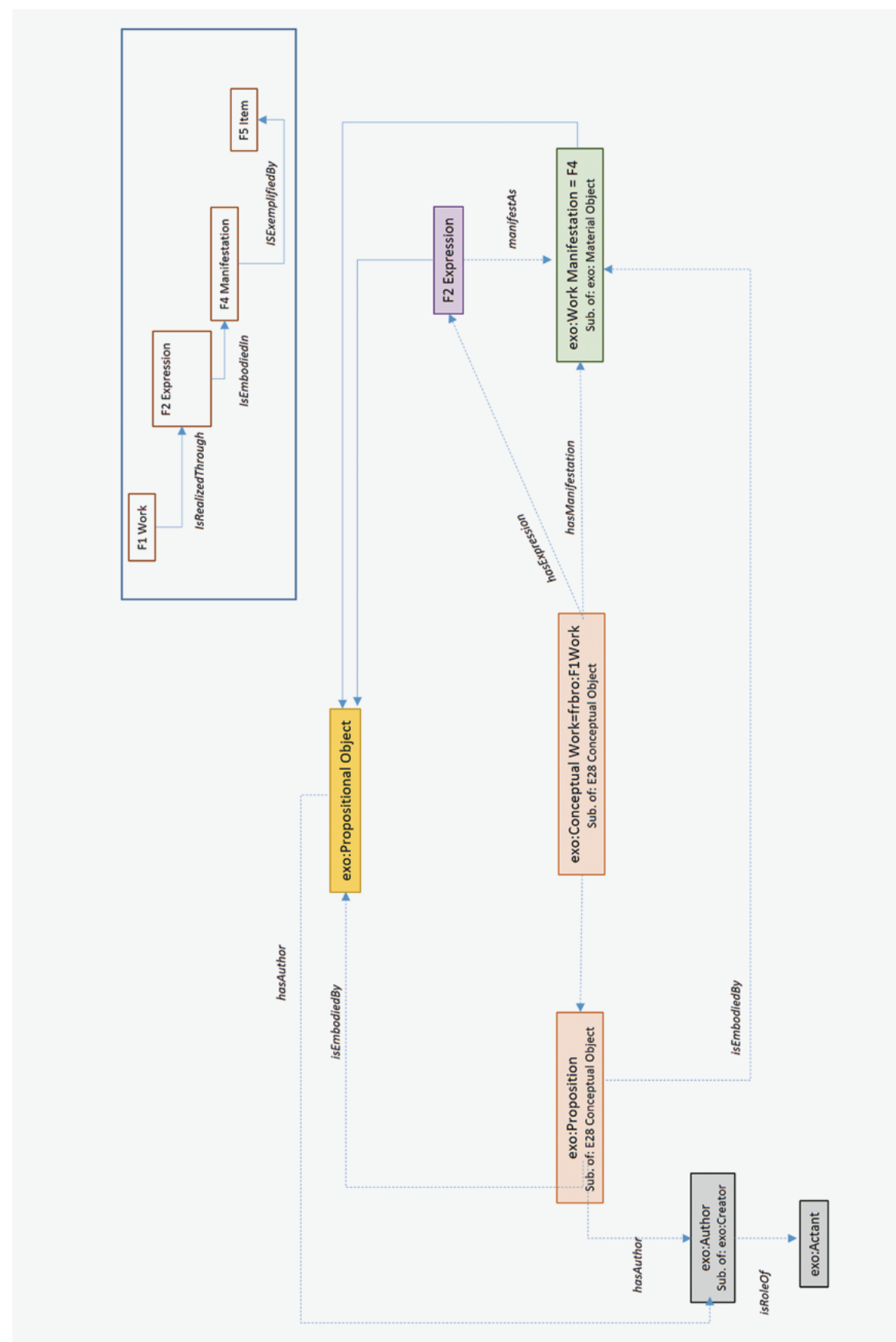


Fig. / Sl. 3 Simplified representation of the discursive-semantic dimension of the OntoExhibit model, 2022. Author: Nuria Rodríguez-Ortega. / Pojednostavnjeni prikaz diskurzivno-semantičke dimenzije modela OntoExhibit, 2022. Autorica: Nuria Rodríguez-Ortega.

On the one hand, the model adopts the distinction and interrelation delineated by FRBRoo between “Work” (F1) — conceived as a purely conceptual and/or intellectual construct — and “Manifestation” (F4) — defined as the specific material realization of that work, acknowledging that a single work may have multiple manifestations. In the OntoExhibit model, the term “Work” is designated as “Conceptual Work,” which is classified as a subclass of CIDOC-CRM’s “Conceptual Object” (E28). Conversely, the term “Manifestation” is designated as “Work Manifestation,” which is categorized under the “Propositional Object” class. Further details on this class will be discussed subsequently. In the FRBRoo model, the relationship between “Work” and “Manifestation” is mediated by the “Expression” (F2) class, defined as the intellectual or artistic realizations of works in the form of identifiable immaterial objects, such as texts, poems, or images. In contrast, the OntoExhibit model additionally incorporates a direct relationship between the two classes, “Conceptual Work” and “Work Manifestation.” This approach resolves scenarios in the art field where it is challenging to identify a particular “Expression” as an intermediate class between a conceptual work and its manifestation or tangible realization. To illustrate, consider a digital art installation that evolves based on viewer interaction. Distinguishing a separate “expression” stage might complicate the model without adding clarity. A similar argument can be made regarding the relationship between a curator’s conceptual work and its tangible manifestation in a physical or digital space that does not have an identifiable “expression” phase in between. Thus, the direct linkage between “Conceptual Work” and “Work Manifestation” in OntoExhibit simplifies the representation of the complex processes involved in the transition from conceptualization to realization of artworks and art exhibitions. This provides a more accurate and efficient framework for capturing the essence of artistic and exhibition practices.

On the other hand, the introduction of two novel classes further enriches the model. The “Proposition” class, a subclass of CIDOC-CRM’s “Conceptual Object” (E28), encapsulates entities that are purely conceptual and/or semantic in nature. The “Propositional Object” class comprises material entities that convey, express, or embody propositions.

At this point, it is important to note that our “Propositional Object” class differs from CRM’s “Propositional Object” (E89). This divergence sparked significant epistemological debate during the conceptualization of OntoExhibit. According to the CRM definition, the “Propositional Object” class (significantly, a subclass of the “Conceptual Work”) can include either a purely conceptual entity (e.g., a topic) and a specific realization or actualization of a proposition or set of propositions (e.g., a poem or a title). However, this definition presents a problematic ambiguity concerning the definition of what is a discursive materialization. This is clearly exemplified by the “title,” which cannot simply be considered a conceptual entity as classified in the CIDOC-CRM (Fig. 4) since a title embodies semantic substance in a distinct form.

E70	- -	Thing
E71	- - -	Human-Made Thing
E24	- - - -	Physical Human-Made Thing
E22	- - - - -	Human-Made Object
E25	- - - - -	Human-Made Feature
E78	- - - - -	Curated Holding
E28	- - - - -	Conceptual Object
E55	- - - - -	Type
E56	- - - - -	Language
E57	- - - - -	Material
E58	- - - - -	Measurement Unit
E98	- - - - -	Currency
E99	- - - - -	Product Type
E89	- - - - -	Propositional Object
E30	- - - - -	Right
E73	- - - - -	Information Object
E29	- - - - -	Design or Procedure
E31	- - - - -	Document
E32	- - - - -	Authority Document
E33	- - - - -	Linguistic Object
E34	- - - - -	Inscription
E35	- - - - -	Title
E36	- - - - -	Visual Item
E37	- - - - -	Mark
E34	- - - - -	Inscription

Fig. / Sl. 4 CIDOC-CRM hierarchy (fragment). / Hijerarhija CIDOC-CRM (fragment).

↑

24 CIDOC-CRM, “E90 class definition.”
 25 CIDOC-CRM, “E89 class definition.”
 26 See note 25.

CIDOC-CRM

E77	-	Persistent Item
E39	- -	Actor
E21	- - -	Person
E74	- - -	Group
E70	- -	Thing
E71	- - -	Human-Made Thing
E24	- - - -	Physical Human-Made Thing
E22	- - - - -	Human-Made Object
E25	- - - - -	Human-Made Feature
E78	- - - - -	Curated Holding
E28	- - - - -	Conceptual Object
E55	- - - - -	Type
E56	- - - - -	Language
E57	- - - - -	Material
E58	- - - - -	Measurement Unit
E98	- - - - -	Currency
E99	- - - - -	Product Type
E89	- - - - -	Propositional Object
E30	- - - - -	Right
E73	- - - - -	Information Object

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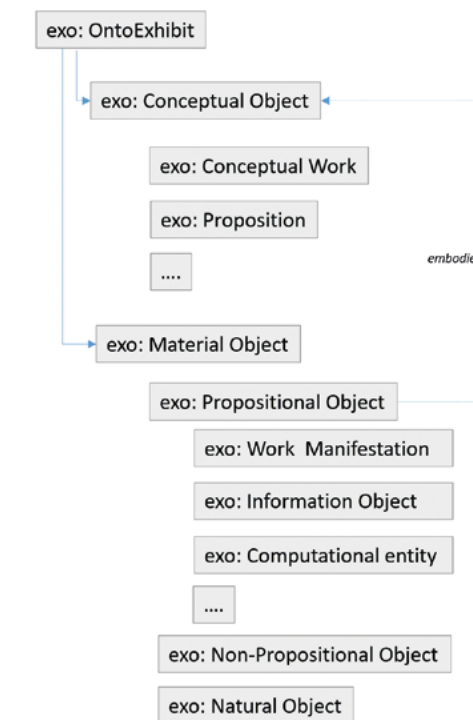


Fig. / Sl. 12 Simplified representation of the OntoExhibit’s “Conceptual Object” and “Material Object” hierarchies, 2023. Author: Nuria Rodríguez-Ortega. / Pojednostavnjeni prikaz hijerarhija „konceptualnih objekata” i „materijalnih objekata” prema modelu OntoExhibit, 2023. Autorica: Nuria Rodríguez-Ortega.

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A title is a specific linguistic materialization and no other, albeit without a physical substrate. Similarly, the “Symbolic Object” class (E90), a subclass of the “Conceptual Object” class, encompasses entities that are unambiguously specific materializations or realizations, such as “traffic signs, emblems, texts, data sets, images, musical scores, multimedia objects, computer program code”.²⁴

To address this ambiguity, the OntoExhibit model explicitly defines a “Propositional Object” as a particular materialization (realization, actualization) of a proposition or set of propositions, whether in the form of a physical artifact (e.g., a painting), a digital object (e.g., a generative video), or a formal expression without a physical or digital substrate (e.g., a poem, a title).

To further elucidate this argument, consider an illustrative example taken from CIDOC-CRM, wherein the propositional object is defined as “the image content of the photograph of the Allied leaders at Yalta published by UPI in 1945”.²⁵ According to OntoExhibit, the modeling of this cultural object is reformulated as follows: the “image content” is conceptualized as the “proposition” while the photograph itself is designated as the “propositional object,” understood as an indivisible unit of content, expression (in this instance, visual), and materiality (here, physical). This approach aims to acknowledge the inherent semantic dimension in materiality. It highlights that this semantic dimension is realized through the interplay between formal expressions and material features—an interplay that CIDOC-CRM obscures by considering material substrates merely as content “carriers.”²⁶ This perspective also discusses the hylomorphic view, which advocates the existence of an idealized and transcendental sphere of semantic contents that exist prior to and independent of any substrate, while recognizing the tangible impact and presence of the conceptual in our material world. Thus, in OntoExhibit, the “Propositional Object” is classified as a subclass of the “Material Object” class (Fig. 12), thereby emphasizing the indissoluble bond between materiality and proposition. This conception of the “Propositional Object” class also implies a reconsideration of the concept of materiality, which will be addressed in more detail later.

Furthermore, since a “Work Manifestation” materializes a “Conceptual Work,” it is classified within OntoExhibit as a subclass of the “Propositional Object” and thus as a subclass of the “Material Object” class (Fig. 12). The following section will examine the implications of this conceptual schema for the art exhibition domain.

Implementation in the art exhibition domain

The implementation of this schema in modelling the art exhibition domain has yielded fruitful results. In accordance with this, OntoExhibit distinguishes between the “Exhibition-Curatorial Project” (classified as a subclass of “Conceptual Work”), which is defined as the intellectual conceptualization of an exhibition, and the “Exhibition” class itself (a subclass of both “Event” and “Work Manifestation”). The former encompasses curatorial discourse, the selection of artworks to be displayed, the decisions concerning visual arrangement and spatial organization, and other intellectual tasks. The latter represents the particular materialization of an “Exhibition-Curatorial Project” (Fig. 5).

It is important to note that the Linked Art model recognizes the distinction between an exhibition as an intellectual concept and as a specific event. However, it appears that the conceptual structures of the Linked Art model consider these categories as independent classes without establishing a direct relationship between them. In other words, within the Linked Art model, an exhibition as an event is not represented as a specific manifestation of a particular exhibition-curatorial project. This approach differs significantly from OntoExhibit as it does not model the connection between conceptual planning and its eventual realization in a material and temporal space.

The OntoExhibit modeling approach offers several advantages over alternative models. Primarily, it underscores the complexity of art exhibitions as dynamic entities encompassing both intellectual creativity and material realization, thereby enriching the representation of the art exhibition domain within digital cultural heritage frameworks. By adopting this model, comprehensive documentation of both the conceptual foundations and the material manifestations of an exhibition becomes feasible. This ensures a richer, more nuanced portrayal of exhibitions in digital archives.

From an epistemological standpoint, the model effectively captures the inherent duality of the exhibition phenomenon. Traditionally, exhibitions have been categorized under the “Event” (E5) class in domain schemas related to art exhibitions. OntoExhibit builds upon this classification by additionally modeling an “Exhibition” as a subclass of “Work Manifestation,” and subsequently, as a subclass of both “Propositional Object” and “Material Object” classes. This modeling illuminates the intrinsic material condition of exhibitions, representing them as material artifacts that, through their very materiality, articulate diverse propositions.

For clear reasons, the exhibition stands as one of the most central propositional objects within the art exhibition domain. It embodies a curatorial discourse, conceptualized as a subclass of the “Proposition” class within the OntoExhibit model (Fig. 5). The “Curatorial Discourse” typically constitutes a complex proposition that may encompass a range of

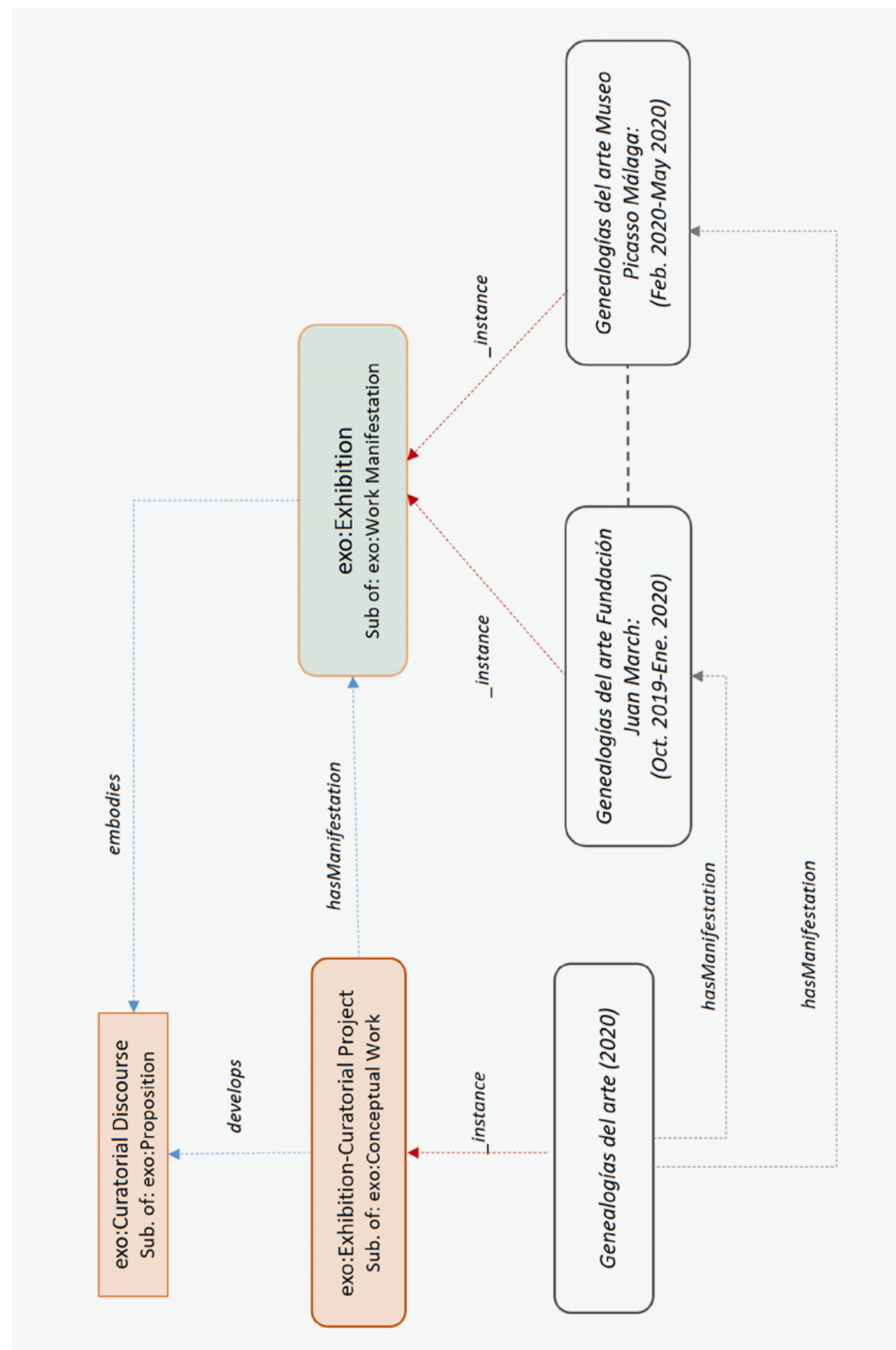


Fig. / Sl. 5 A simplified representation of the “Exhibition-Curatorial Project” and the “Exhibition” classes within the OntoExhibit model, 2022. Author: Nuria Rodríguez-Ortega. / Pojednostavnjeni prikaz klasa „izložba” i „izložba” unutar modela OntoExhibit, 2022. Autorica: Nuria Rodríguez-Ortega.

properties or relationships that establish connections between exhibitions and exhibition-curatorial projects. For example, projects that aim to reconstruct historical exhibitions from existing documentation solely to capture their material manifestation and visual impact may employ the property “is reenactment of” to establish a connection between the exhibitions (Fig. 7). Nevertheless, not all revisits of historical exhibitions are solely reconstructions or recreations. In some instances, these exhibitions undergo significant reformulation, evolving into distinct exhibition projects with their own curatorial objectives. A prime example is the *Iconoclash Digital Experience* (2023),²⁷ which builds upon the *Iconoclash* exhibition curated by Bruno Latour and Peter Weibel in 2002 at ZKM-Karlsruhe. In this instance, the original exhibition serves as a foundation for developing a new exhibition project with specific curatorial intentions. For such cases, the OntoExhibit model employs the property “is an interpretation of” to connect the exhibition-curatorial projects and the property “is a version of” to link the exhibitions (Fig. 7).

Consequently, this framework permits a nuanced examination of how a curatorial-exhibition project undergoes redefinition or reformulation across different materializations. It offers insights into the shifts or transformations in its discursive propositions and supports an in-depth exploration of the various interpretations and discursive evolutions that historical exhibitions may experience when reimagined through contemporary projects.

The OntoExhibit model also integrates the “Proposition Assignment” class to effectively represent and analyze the diversity of “Propositions” that certain “Propositional Objects”—including artworks and exhibitions themselves—assign or predicate about entities within the exhibition ecosystem. Consider, for example, Beatrice von Bismarck’s monograph *The Curatorial Condition* (2022), in which the author presents a thesis about the notion of the “curatorial condition” and introduces new concepts into the curatorial discourse while also interpreting historical exhibitions to support her arguments.

As outlined in Fig. 8, the OntoExhibit framework enables intricate modeling of the interconnections established between interpretations, exhibitions, and concepts, prompting the formulation of critical inquiries, such as: What specific interpretations are associated with each exhibition? Do certain exhibitions share common interpretative frameworks? What overarching theoretical framework underpins these interpretations? How do exhibitions serve as theoretical objects, contributing to the enrichment of the discourse within the exhibition-curatorial field?

The “Propositional Object” class also encompasses the intellectual and cultural productions displayed in exhibitions. In the OntoExhibit model, for example, a painting by Pablo Picasso, a traditional Baoulé mask from the Bouaké region of the Ivory Coast, or a generative video installation by Anne Riedler are classified as instances of the “Propositional

²⁷ See the *Iconoclash Digital Experience* website.

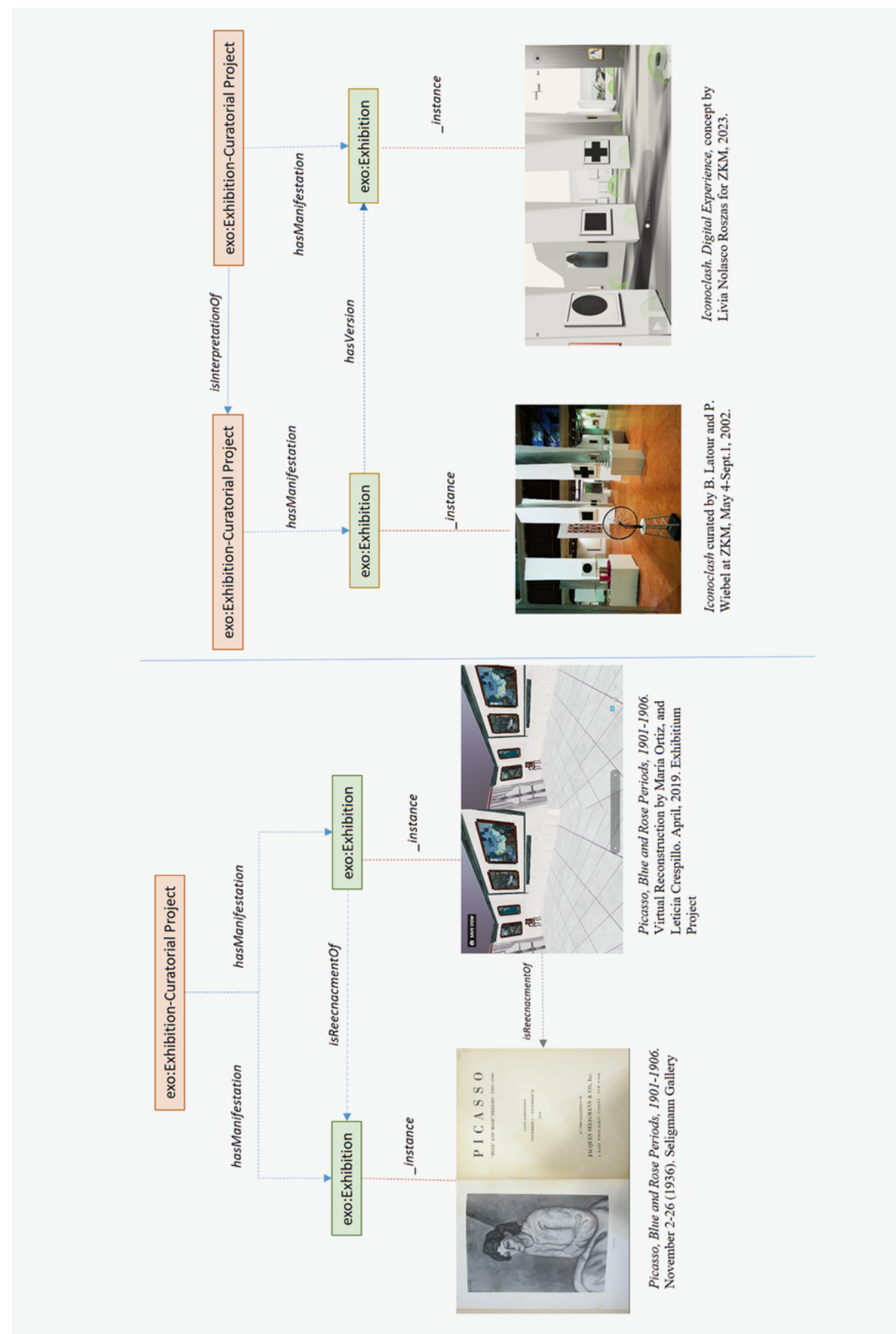


Fig. / Sl. 7 Relationships between exhibitions modeled with the OntoExhibit model (examples), 2022. Author: Nuria Rodríguez-Ortega. / Odnosi između izložbi prema modelu OntoExhibit (primjeri), 2022. Autorica: Nuria Rodríguez-Ortega.

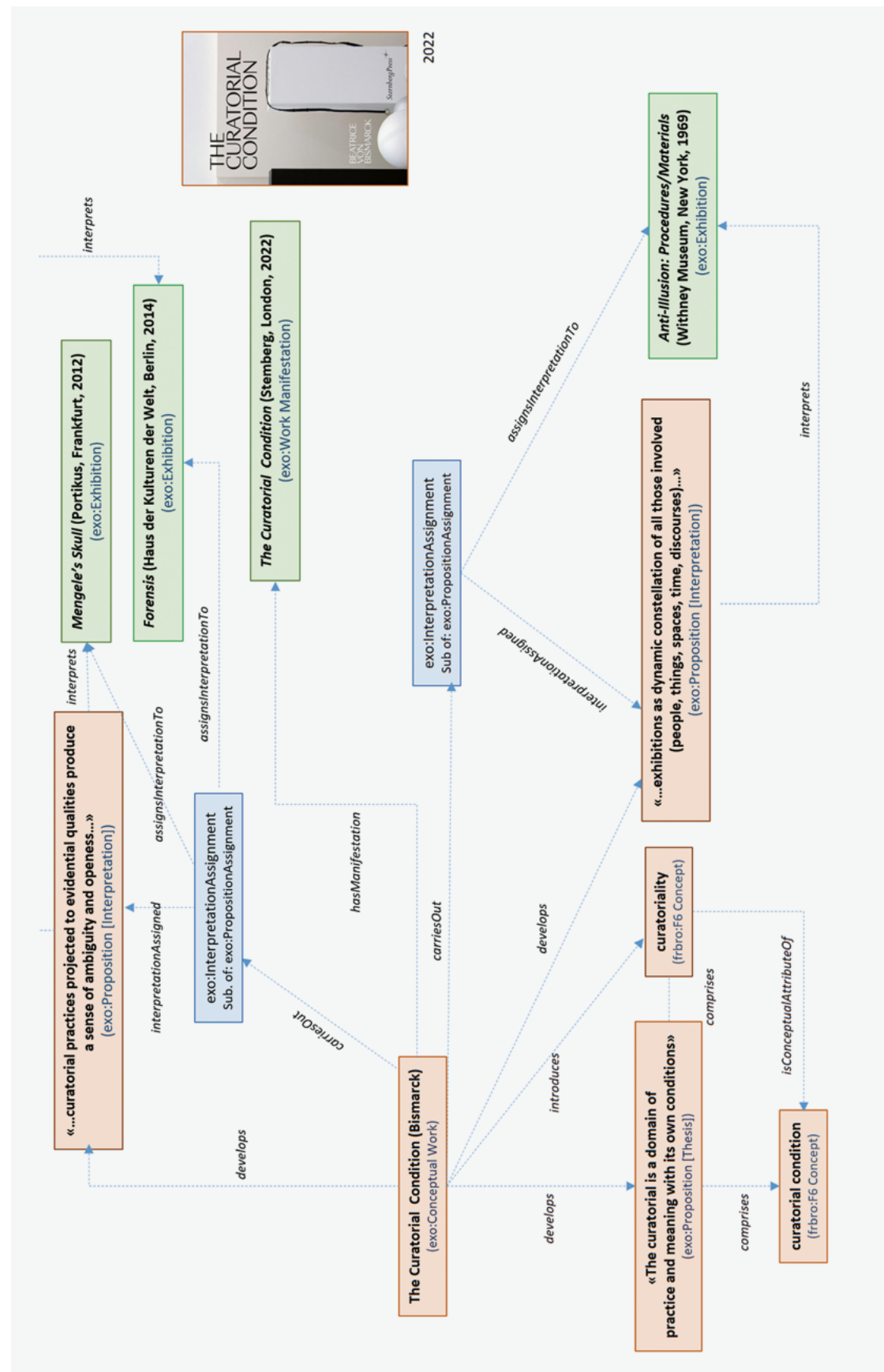


Fig. / Sl. 8 Application of the OntoExhibit model to the conceptual, theoretical and interpretative dimensions of the art exhibition domain, 2022. Author: Nuria Rodríguez-Ortega. / Primjena modela OntoExhibit na konceptualne, teorijske i interpretativne dimenzije domene umjetničkih izložbi, 2022. Autorica: Nuria Rodríguez-Ortega.

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Object” class. As propositional objects, they embody propositions and convey symbolic value.

It is important to note that within the OntoExhibit model, the concept of “artwork” is a subclass of the “Propositional Object” class, which, in turn, is a subclass of the “Material Object” class (for further details, please refer to the subsequent section, Fig. 12). In the context of an exhibition, the items on display belong to the “material object” class, some of which may be regarded as falling within the category of what is understood in the Western sphere as “artwork.” This approach is intended to acknowledge that the concept of “artwork” is a Western theoretical construct that cannot be applied in a strict manner to all cultural and intellectual productions included in exhibitions.

The definition and systematization of the types of propositions that cultural and intellectual productions can embody and convey as “propositional objects” is still an ongoing process of research and development within the *Complexhibit Project*. Subsequent iterations of the model will address this task in greater detail, building upon the foundations provided by previous studies.²⁸ In any case, the OntoExhibit model offers a foundational framework for analyzing the semantic-discursive sphere emanating from exhibitions where works on display are included (Fig. 9). Consequently, the OntoExhibit model allows for an exploration of the resignification that the curatorial discourse operates on them, as well as an examination of how this resemantization intersects with the various interpretations proposed about the works exhibited over time.

This model also enables the representation and analysis of social media interactions and the wide range of activities associated with exhibitions (Fig. 10).

The examples presented demonstrate the capacity of the OntoExhibit model to capture the discursive and semantic complexities that characterize the exhibition domain. In doing so, it opens avenues for understanding how exhibitions extend beyond themselves to influence and engage with broader social and discursive networks.

THE POST-ANTHROPOCENTRIC
 APPROACH: REVISITING THE CONCEPT
 OF AGENCY

OntoExhibit also espouses a post-anthropocentric perspective that acknowledges the growing involvement of non-human agencies in the field of exhibition making, curatorial work and artistic practices. This approach has entailed the incorporation of specific classes within the model and, once more, has prompted a critical examination of the CIDOC-CRM hierarchy.

The CIDOC-CRM’s “Actor” class (E39) comprises two subclasses: “People” and “Group (of people).” If we acknowledge

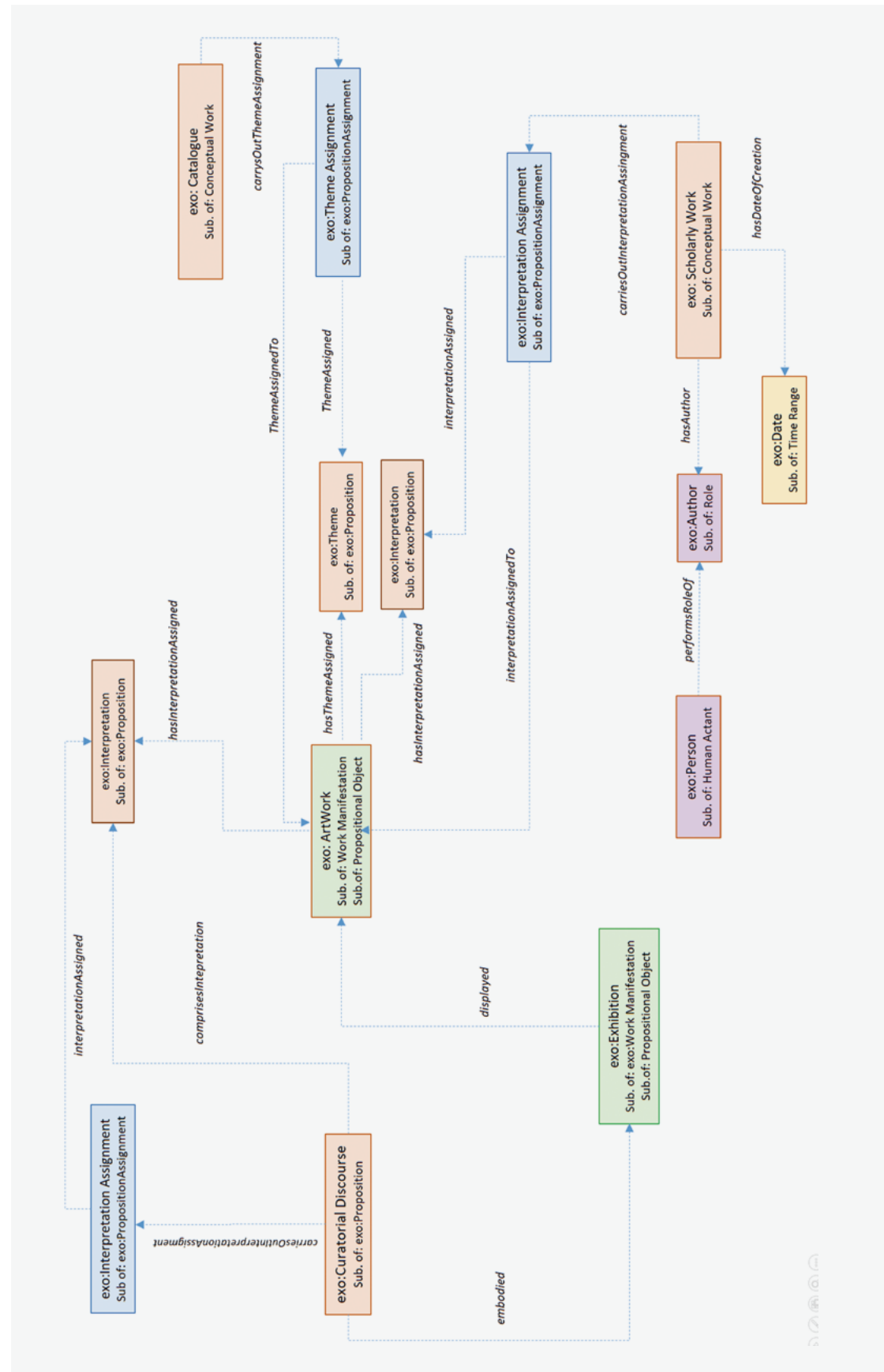


Fig. / Sl. 9 Application of the OntoExhibit model to the conceptual, theoretical and interpretative dimensions of artworks included in exhibitions, 2022. Autor: Nuria Rodríguez-Ortega.
 / Primjena modela OntoExhibit na konceptualne, teorijske i interpretativne dimenzije umjetničkih djela uključenih u izložbe, 2022. Autorica: Nuria Rodríguez-Ortega.

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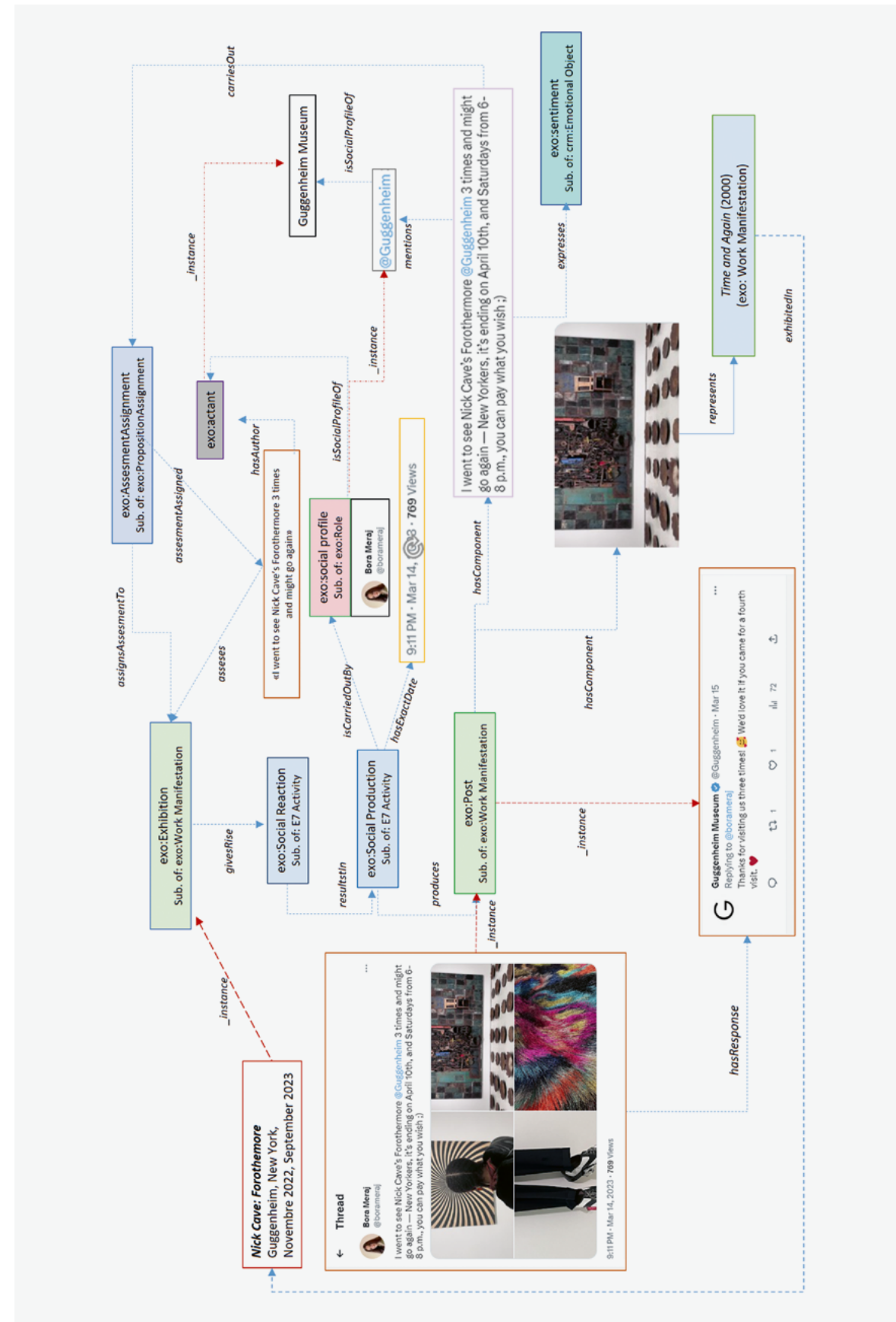


Fig. / Sl. 10 Modeling social interactions related to the art exhibition domain with the OntoExhibit model, 2022. Autor: Nuria Rodríguez-Ortega.
 / Modeliranje društvenih interakcija povezanih s domenom umjetničkih izložbi s pomoću modela OntoExhibit, 2022. Autorica: Nuria Rodríguez-Ortega.

that the primary attribute of the “actor” class is the capacity for agency, this classification inherently restricts this capacity to human actors, the instances that fall under “People” and “Group.” Therefore, this classification becomes problematic when considering the inclusion of non-human agents in creative and curatorial processes. Moreover, the definition of the “Actor” class specifies that it comprises individuals or groups “capable of performing intentional actions for which they can be held responsible.”²⁹ This raises significant questions regarding the concept of agency itself and the entities that can be considered as agents. CIDOC-CRM’s implicit narrow definition of agency, limited to actions resulting from intentional human acts, excludes the potential agency of non-human entities, especially computational ones.

Furthermore, CIDOC-CRM classifies both physical and conceptual objects under the “Human-Made Thing” class (E71) (Fig. 12), which results in all productions, whether conceptual or physical, being classified as human productions. This classification becomes controversial when addressing outputs produced by generative AI technologies and the involvement of AI systems in exhibition-curatorial processes.

While acknowledging ongoing debates concerning the genuine authorship of computational entities and the degree of intentionality that can be attributed to non-human entities, it is evident that this classification is inadequate for representing the contemporary scenario in which technological entities exhibit a degree of autonomy in decision-making, action execution, and co-creation processes. If the objective is to develop formal models that more accurately represent this evolving landscape, it is imperative to consider how the concept of agency can be extended in these models.

As an interim solution, OntoExhibit has eliminated the “Human-Made Thing” class from its conceptual framework, and has introduced two new distinct classes: non-human actants (e.g., biological species integrated into exhibitions and artworks) and techno-actants (e.g., deep neural networks) (Fig. 11). It is important to note that the techno-actant has not been classified as a subclass of the non-human actant. This acknowledges that such computational entities cannot be considered entirely alienated from the non-human realm. These new classes permit the examination of novel scenarios within the art exhibition domain. For example, the *Bucharest Biennial 2022*, which “was curated” by an artificial intelligence system named Jarvis, represents such a scenario.³⁰ Similarly, the project *The Next Biennial Should Be Curated by a Machine* (2021),³¹ employs a combination of generative and multimodal AI models to generate both synthetic texts and images derived from human artworks, as well as to weave them together in unconventional itineraries shaped by AI logics. Furthermore, these classes accommodate artistic and cultural productions that emerge from co-creation processes involving generative AI models. This broadens the model’s capacity to reflect the dynamic interplay between human and non-human creativity in the contemporary art exhibition landscape.

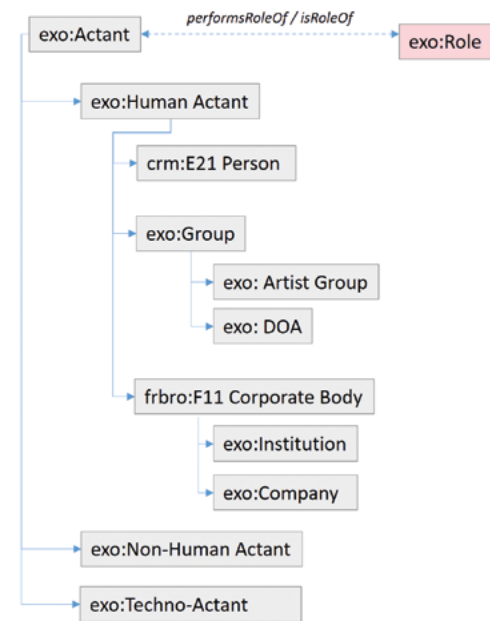


Fig. / Sl. 11 OntoExhibit's actant hierarchy, 2023. Author: Nuria Rodríguez-Ortega. / Hijerarhija aktanata prema modelu OntoExhibit, 2023. Autorica: Nuria Rodríguez-Ortega

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²⁹ CIDOC-CRM, “E39 class definition.”

³⁰ Bucharest Biennial. See the website.

³¹ Krysa et al., *The Next Biennial Should be Curated by a Machine*. See the website.

³² In the CIDOC-CRM, the property “carries / is carried by” is defined as: “identifies an instance E90 Symbolic Object carried by an instance of E18 Physical Thing.” CIDOC-CRM, “P128 property definition.” See the website.

RECONSIDERING THE CONCEPT OF MATERIALITY

In the OntoExhibit model, the “Material Object” class is defined as comprising entities that have a material existence, and that cannot be confined to the purely conceptual or intellectual realm. This material existence may be physical (e.g., a painting) or non-physical (e.g., a digital image or a poem). In other words, they are entities whose existence is not contingent on a physical substrate, yet they are not limited to the purely conceptual or intellectual domain. Similarly, these material entities (physical, formal, or digital) encompass both manifestations or realizations of specific propositions, which have been designated as “Propositional Objects” in OntoExhibit, and entities that are not intellectual or cultural productions, such as physical devices, biological entities, or natural elements.

This reclassification leads to a nuanced re-evaluation of the concept of “materiality” compared to the CIDOC-CRM classification. In the CIDOC-CRM model, materiality is implicitly equated with physicality. The CIDOC-CRM establishes a clear disjunction between conceptual and physical objects (Fig. 12), which leads to a problematic binarism: everything that is not conceptual must be physical, and everything without a physical substrate must be conceptual. This explains why a title, a multimedia object, or a computer program code are classified as conceptual objects, as previously mentioned. This binary view also implies a separation between the physical object (conceptualized as a “carrier”) and the semantic/symbolic content.³² This separation suggests that materiality is synonymous with physical presence on the one hand and that semantic/symbolic content exists independently from the substrate on the other hand.

In contrast to this perspective, the OntoExhibit model proposes a broader understanding of a “material object” as any entity that manifests through formal, digital, or physical realization (Fig. 12). This broader definition aims to transcend the reductionist view that equates materiality solely with physicality, a perspective that frequently excludes computational or digital objects from being considered as part of the material world. Adopting this approach, OntoExhibit challenges the traditional CIDOC-CRM classification, advocating for a more inclusive understanding of materiality that encompasses, among other entities, digital and computational objects. This perspective acknowledges the tangible impact and presence these entities have despite their lack of a conventional physical substrate. It emphasizes the necessity of rethinking materiality in the digital age, where the boundaries between the physical and the digital, the tangible and the intangible, are becoming increasingly indistinct. In turn, the concept of “Propositional Object,” as previously defined, unites the material with the conceptual, thereby overcoming the also problematic dichotomy between conceptual objects and material objects.

E77	-	Persistent Item
E39	- -	Actor
E21	- - -	Person
E74	- - -	Group
E70	- -	Thing
E71	- - -	Human-Made Thing
E24	- - - -	Physical Human-Made Thing
E22	- - - - -	Human-Made Object
E25	- - - - -	Human-Made Feature
E78	- - - - -	Curated Holding
E28	- - - - -	Conceptual Object
E55	- - - - -	Type
E56	- - - - -	Language
E57	- - - - -	Material
E58	- - - - -	Measurement Unit
E98	- - - - -	Currency
E99	- - - - -	Product Type
E89	- - - - -	Propositional Object
E30	- - - - -	Right
E73	- - - - -	Information Object

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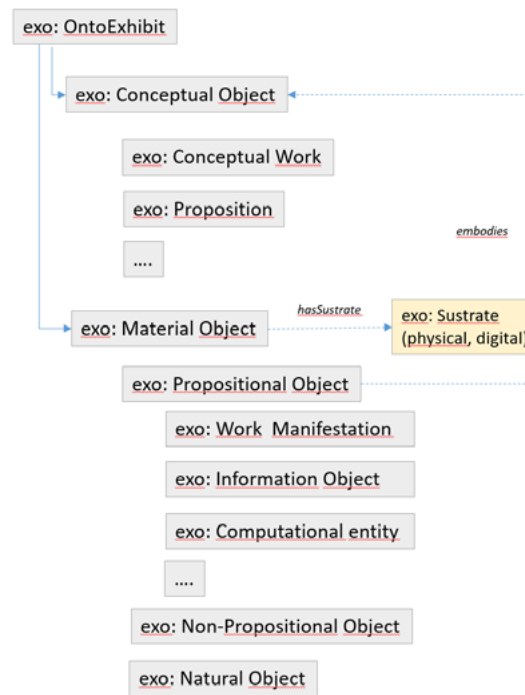


Fig. / Sl. 12 Simplified representation of the OntoExhibit's "Conceptual Object" and "Material Object" hierarchies, 2023. Author: Nuria Rodríguez-Ortega. / Pojednostavnjeni prikazhijerarhija „konceptualnih objekata” i „materijalnih objekata” prema modelu OntoExhibit, 2023. Autorica: Nuria Rodríguez-Ortega.

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CONCLUSIONS

This article presents an examination of the OntoExhibit model and its approach to modeling the art exhibition domain. It draws attention to several pivotal conclusions regarding the epistemological impacts, conceptual challenges, and the broader implications of knowledge modeling and representation within the context of semantic web technologies and cultural heritage.

In light of these findings, it becomes evident that a critical reexamination of established reference models is imperative. These models frequently contain conceptual assumptions and epistemological conventions that may not adequately address the evolving complexities of cultural ecosystems. This article argues that any conceptual modeling or knowledge representation must be undertaken with a critical reassessment of the assumptions inherent to conceptual models in order to align with the requirements of complex cultural ecosystems. OntoExhibit addresses these assumptions and, as a consequence, critically discusses their limitations as part of its construction process. This enables it to offer a more nuanced and expanded representation of the art exhibition domain. Furthermore, the study highlights the importance of recognizing the construction of semantic models and ontologies as an epistemological endeavor, where conceptual redefinitions of the cultural domain are of significant concern.

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BIBLIOGRAPHY / POPIS LITERATURE

Andalex Project. <https://andalexproject.iarthislab.eu/> (date of access: July 10, 2024).

Berners-Lee, Tim; Hendler, James; Lassila, Ora. "The Semantic Web," *Scientific American* 284, 5 (2001), 34–43.

Bucarest Biennial. <https://bucharestbiennale.org/curators/> (date of access: 10 July 2024).

Carboni, Nicola; Luca, Livio de. "An Ontological Approach to the Description of Visual and Iconographical Representations." *Heritage* 2 (2019), 1191–1210.

Carboni, Nicola; Usel, Thibault; Joyeux-Prunel, Béatrice. "Intégrer des données historiques spatiotemporelles. L'intérêt du Linked Open Data." *Humanistica* 2023, Association francophone des humanités numériques, Jun 2023, Genève, Suisse. hal-04110759.

CIDOC-CRM. <https://www.cidoc-crm.org/> (date of access: July 10, 2024).

CIDOC-CRM. "E39 class definition." https://cidoc-crm.org/html/cidoc_crm_v7.1.2.html#E39 (date of access: July 10, 2024).

CIDOC-CRM. "E89 class definition." https://cidoc-crm.org/html/cidoc_crm_v7.1.2.html#E89 (date of access: January 12, 2024).

CIDOC-CRM. "E90 Definition." https://cidoc-crm.org/html/cidoc_crm_v7.1.2.html#E90 (date of access: July 10, 2024).

CIDOC-CRM. "P128 property definition." https://cidoc-crm.org/html/cidoc_crm_v7.1.2.html#P128 (date of access: July 10, 2024).

Complexhibit Project. <https://complexhibit.eu/> (date of access: July 10, 2024).

Exhibitium Project. <https://exhibitium.es/> (date of access: July 10, 2024).

FRBRoo. <https://www.iflstandards.info/fr/frbr/frbroo.html> (date of access: July 10, 2024).

Gruber, Thomas R. "A translation approach to portable ontologies." *Knowledge Acquisition* 5, 2(1993), 199–220.

Iconoclash Digital Experience, 2023. <https://iconoclash.beyondmatter.eu/> (date of access: July 10, 2024).

Krysa, Joasia; Impett, Leonardo; Cetinic, Eva. *The Next Biennial Should be Curated by a Machine*, 2021. <https://ai.biennial.com/> (date of access: July 12, 2024).

Linked Art. <https://linked.art/> (date of access: July 10, 2024).

Lodi, Giorgia et al. "Semantic Web for Cultural Heritage Valorisation." 3–37. In *Data Analytics in Digital Humanities. Multimedia Systems and Applications*, ed. Shalin Hai-Jew. Cham: Springer, 2017. https://doi.org/10.1007/978-3-319-54499-1_1

Mancini, Maria Giovanna; Sauro, Luigi. "A Conceptual Model for Art Criticism." *Život Umjetnosti* 105, n. 2 (2019): 138–157. doi: 10.31664/zu.2019.105.06.

Museo del Prado Semantic Model. <https://www.museodelprado.es/grafico-de-conocimiento/modelo-ontologico> (date of access: July 10, 2024).

Rodríguez-Ortega, Nuria; Cruces Rodríguez, Antonio. "Development of Technological Ecosystems for Cultural Analysis: The Case of Expofinder System and Art Exhibitions." *Digital Scholarship in the Humanities* 34, n. 2 (2019): 423–448. doi.org/10.1093/llc/fqy018 (date of access: January 12, 2024).

Rodríguez-Ortega, Nuria; Roldán García, M. Mar; Díez Platas, M.ª Luisa; Salvachúa, Martín. *OntoExhibit*. <https://github.com/Complexhibit-Project/OntoExhibit> (date of access: July 10, 2024).

Sartini, Bruno; Baroncini, Sofía; Van Erp, Marieke, et al. "ICON: An Ontology for Comprehensive Artistic Interpretations." *Journal on Computing and Cultural Heritage* 16, n. 3 (2023): 1–39.

Smiraglia, Richard P.; Scharnhorst, Andrea, ed. *Linking Knowledge. Linked Open Data for Knowledge Organization and Visualization*. Baden-Baden: Ergon Verlag, 2021.

Van den Heuvel, Charles; Zamborlini, Veruska. "Modeling and Visualizing Storylines of Historical Interactions. Kubler's Shape of Time and Rembrandt's Night Watch." 99–141. In *Linking Knowledge. Linked Open Data for Knowledge Organization and Visualization*, ed. Richard P. Smiraglia and Andrea Scharnhorst. Baden-Baden: Ergon Verlag, 2021.

Van Ruymbeke, Muriel; Hallot, Pierre; Nys, Gilles-Antoine; Billen, Roland. "Implementation of Multiple Interpretation Data Model Concepts in CIDOC CRM and Compatible Models." *Virtual Archaeology Review* 9, n. 19 (2018): 50–65.

Wijesundara, C.; Monika, W.; Sugimoto, S. "A Metadata Model to Organize Cultural Heritage Resources in Heterogeneous Information Environments." In: *Digital Libraries: Data, Information, and Knowledge for Digital Lives*, eds. S. Choemprayong, F. Crestani, S. Cunningham. ICADL 2017. Lecture Notes in Computer Science, vol. 10647. Cham: Springer, 2017. https://doi.org/10.1007/978-3-319-70232-2_7.

Wilkinson, Mark D.; Dumontier, Michel; Aalbersberg, IJsbrand Jan et al. "The FAIR Guiding Principles for scientific data management and stewardship." *Sci Data* 3, 160018 (2016). <https://doi.org/10.1038/sdata.2016.18>.