Artigo Original

Encontros Bibli

ANALYSIS AND CORRESPONDENCE BETWEEN THE ENTITIES OF THE EUROPEANA DATA MODEL, IFLA LRM, AND BIBFRAME CONCEPTUAL MODELS

Análise e correspondência entre as entidades dos modelos conceituais Europeana Data Model, IFLA LRM E BIBFRAME.

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ABSTRACT

Objective: To propose the harmonization between the EDM, BIBFRAME, and IFLA LRM models with the purpose of analyzing the equivalence of entities to enable the interoperability between systems that use these conceptual models as a basis.
Method: This research is characterized as exploratory and descriptive with a qualitative approach, in which a bibliographic survey was used to identify the studies already carried out on the topic. In addition, the analysis of entities was based on the methodology substantiated by Pierre et al. (1999), Taniguchi (2018), Arakaki (2019), and Carrasco (2019).
Results: From the analysis of the models, six ontological categories of entities were identified: (i) Intellectual Content, (ii) Subject, (iii) Concrete Unit, (iv) Agent, (v) Space-time, and (vi) Reification. Consistent equivalences were observed between the entities, their functionalities, and terminology in most categories, except for the entities of the Intellectual Content category and the structuring of the Concrete Unit category.
Conclusions: It was concluded that the most notable difference between the models was expressed in the Intellectual Content category, and that, because they are based on the cataloging tradition, the IFLA LRM and BIBFRAME models have functionally equivalent entities, while the EDM model, focused on the cultural heritage object itself, does not have any entity that may be mapped in this category. Likewise, a structural difference was found in the Concrete Unit category, in which the EDM model makes a distinction between the object itself and its digital representation, whereas such a distinction occurs in the Intellectual Content category for the IFLA LRM and BIBFRAME models.
KEYWORDS: Europeana Data Model; BIBFRAME; IFLA LRM; Cataloging; Metadata.

RESUMO

Objetivo: objetiva-se propor a harmonização entre os modelos EDM, BIBFRAME e IFLA LRM, com o propósito de analisar a equivalência de entidades para possibilitar a interoperabilidade entre sistemas que utilizam como base esses modelos conceituais.
Método: esta pesquisa se caracteriza como de natureza exploratória e descritiva com abordagem qualitativa, na qual utiliza-se do levantamento bibliográfico para a identificação dos estudos já realizados a respeito da temática. Além disso, para a análise de entidades, pauta-se na metodologia fundamentada por Pierre *et al.* (1999), Taniguchi (2018), Arakaki

(2019) e Carrasco (2019).
Resultados: a partir da análise dos modelos, foram identificadas seis categorias ontológicas de entidades: (i) Conteúdo Intelectual; (ii) Assunto; (iii) Unidade Concreta; (iv) Agente; (v) Espaço-tempo, e (vi) Reificação. Observou-se equivalências consistentes entre as entidades, suas funcionalidades e terminologia na maior parte das categorias, tendo como exceção as entidades da categoria Conteúdo Intelectual e a estruturação da categoria Unidade Concreta.
Conclusões: conclui-se que a diferença mais notável entre os modelos se expressa na categoria Conteúdo Intelectual, e que o IFLA LRM e o BIBFRAME por serem modelos fundamentados na tradição catalográfica têm entidades funcionalmente equivalentes, ao passo que o EDM, como modelo voltado ao objeto de patrimônio cultural em si, não possui nenhuma entidade que possa ser mapeada nessa categoria, Outrossim,constatou-se há uma diferença estrutural na categoria Unidade Concreta, onde o EDM faz uma distinção entre o objeto em si e sua representação digital, ao passo que nos modelos IFLA LRM e BIBFRAME, tal distinção ocorre na categoria Conteúdo Intelectual.
PALAVRAS-CHAVE: Europeana Data Model; BIBFRAME; IFLA LRM; Catalogação; Metadados.

1 INTRODUCTION

The needs and expectations of users with information systems have become more complex and diversified due to communicational and technological transformations, especially regarding retrieving information quickly and effectively in various information environments.

Given this scenario, new cataloging guidelines and standards have been developed to better adapt catalogs to the digital environment, thus providing a better user experience. Thus, a new perspective emerged for the description of objects that comes to be analyzed from the database conceptual modeling step (ARAKAKI, 2020).

In the conceptual modeling step, the modeler performs an abstraction activity, from which they seek to represent the formalization of a domain. According to Teixeira (2009, p. 50), "[...] it is necessary to favor characteristics more important to the objectives that are sought. Some characteristics that are important to one group may be irrelevant to another group." Therefore, the creation of conceptual models requires the process of conceptualization of the domain to be represented.

In addition, because they present the highest level of abstraction, conceptual models provide "[...] a closer view of the way users visualize the data and defines specifications necessary for the quality of the information of the computerized environment to be created" (FUSCO, 2010, p. 99).

According to Marcondes (2016, p. 71), "[...] the promise of conceptual models is to facilitate interoperability between collections from different institutions". Given this, establishing an interoperable environment is important to prevent content loss and enable data sharing more efficiently.

With the advent of the Semantic Web and Linked Open Data technologies, integrating digital collections of archives, libraries, and museums published on the Web becomes feasible. However, because they do not need the intermediation of catalog management systems, the interoperability issue of such heterogeneous systems has become widely discussed in Information Science (MARCONDES, 2016).

According to Triques and Arakaki (2020, p. 5), "[...] over the years, studies have addressed these issues from various instruments such as metadata standards and schemes, controlled vocabularies, thesauri, and ontologies". On the other hand, the interoperability between the systems may be compromised due to this diversified creation of such instruments.

Thus, the harmonization of conceptual models emerges as a strategy to be adopted in an attempt to solve interoperability problems, given that it is understood as a procedure in which the terminological-conceptual consensus is established. Hence, this methodology allows for integrating heterogeneous digital collections (CARRASCO, 2019).

Therefore, this article aims to propose the harmonization between the Europeana Data Model (EDM), IFLA Library Reference Model (IFLA LRM), and BIBFRAME conceptual models to analyze the equivalence of entities for the establishment of better data sharing between the systems.

This research is characterized as exploratory and descriptive with a qualitative approach. As for the methodological procedures, we resorted to bibliographic research to survey the literature already produced on the theme. For this purpose, primary, secondary, and tertiary sources were consulted, as well as the *Base de Dados em Ciência da Informação* (BRAPCI, Information Science Database), dissertations and theses available on the *Biblioteca Digital Brasileira de Teses e Dissertações* (BDTD, Brazilian Digital Library of Dissertations and Theses), and the Scientific Electronic Library Online (SciELO). In addition, for the construction of the harmonization proposal, the methodology used by Pierre et al. (1999), Taniguchi (2018), Arakaki (2019), and Carrasco (2019) was considered.

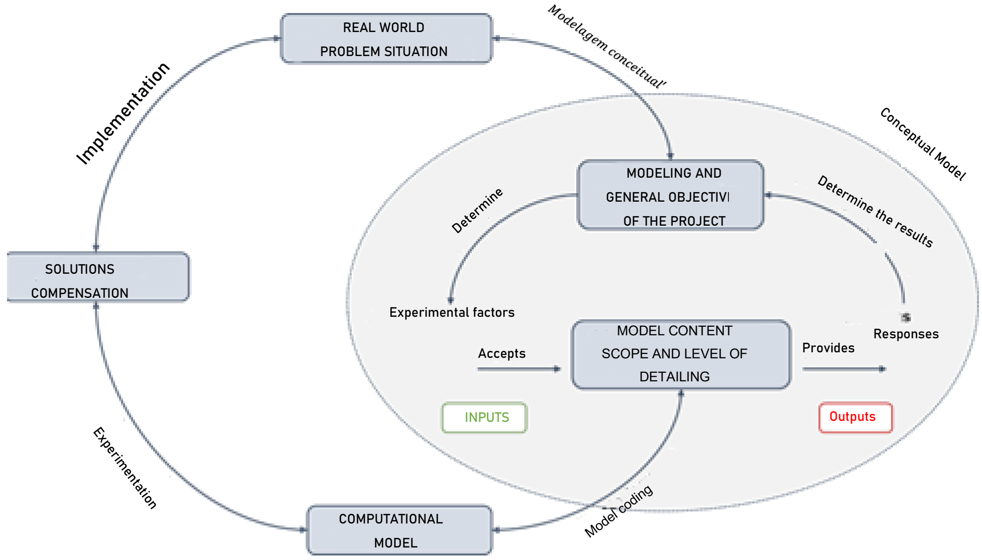
2 CONCEPTUAL MODELS

The development of conceptual models is related to the process of abstraction from an actual or proposed system (ROBINSON et al., 2010). According to Marcondes (2016, p. 71), conceptual models may be defined as "[...] formal representations of a domain in terms of the entity classes and their existing relationships". Thus, the description of the concepts and their possible relationships occurs in an attempt to simplify reality.

> In general, the notion of conceptual modeling expressed in the simulation and modeling literature is vague and ill-defined, with varying interpretations as to its meaning. What seems to be in agreement is that it refers to the early stages of a simulation study. "This implies a sense of moving from the recognition of a problem situation to be addressed with a simulation model to a determination of what is going to be modeled and how" (ROBINSON et al., 2010, p. 8).

Thus, a modeling simulation is characterized as a repetitive step, refined several times until the desired objective is reached, as presented in Figure 1.

Figure 1 – The conceptual model in the simulation project life cycle.



Source: Adapted from Robinson et al. (2010, p. 11).

It is observed that the simulation stage has four main phases: conceptual modeling, model coding, experimentation, and implementation. As a consequence of each phase, a conceptual model, a computational model, solutions to the problem situation, or a better understanding of the real world and possible improvements are obtained, respectively (ROBINSON et al., 2010).

Thus, the cyclic step of the simulation stage is proven through the use of the double arrows, given that they establish the interactions between the phases and their respective results. In addition, the conceptual model, which is highlighted within the gray ellipse, presents four main elements related through the arrows indicated in the illustration, namely objectives, inputs (experimental factors), outputs (responses), and model content (ROBINSON et al., 2010).

In turn, the Entity-Relationship (E-R) modeling is a technique that emerged in the mid-twentieth century with the purpose of describing the attributes of data, as well as establishing relationships between them. This procedure assists in developing relational databases (COYLE, 2016).

Consequently, the *Europeana* project started in 2005 with the purpose of gathering, storing, and making available on its platform the European cultural heritage. However, it was only in 2010 that the Europeana operating system was concretized (EUROPEANA, 2017). In addition, Europeana uses the Linked Data principles and

> In addition, Europeana uses the Linked Data principles and [...] created the standardized resource description model Europeana Data Model (EDM) to facilitate the aggregation of metadata in Europeana and enable descriptive enrichment through links to other resources and datasets on the Web, which opened the prospects of identifying and expressing various metadata of cultural contextualization among the assets made available (RIBEIRO; SOUSA; BORGES, 2020, p. 252).

In addition, the Bibliographic Framework (BIBFRAME) is also a model developed based on Linked Data foundations. The release of the first version of BIBFRAME by the Library of Congress (LC) took place in mid-2011, with the intent of providing interoperability between libraries through the implementation of bibliographic data connected to the Web (SILVA, 2022).

Moreover, the IFLA Library Reference Model (IFLA LRM) was published in 2017 to create general principles governing the logical structure of bibliographic information. Hence, the model does not distinguish how data are stored, given that they are considered bibliographic information and contained within its scope (RIVA; LE BOUEF; ŽUMER, 2017). Regarding the application of the IFLA LRM model data on the Semantic Web,

> [...] the IFLA LRM model has already been instantiated for possible applications. The result of this instantiation was a single, simplified, and logically consistent model that covers all aspects of the bibliographic data. Thus, the way the LRM model is being presented, it is configured as a conceptual model. However, by its instantiation and the creation of namespaces, it can provide mapping with other metadata standards (ARAKAKI, 2020, p. 177).

In summary, it was possible to verify the concepts regarding conceptual models and the simulation process for their construction. Moreover, in this section, a brief history of the following models was presented: EDM, IFLA LRM, and BIBFRAME. These, in turn, are correspondent concerning the elaboration of initiatives based on the Linked Open Data concepts in which they may be applied to the Semantic Web. Therefore, in the following subsections, the structure of these models will be more detailed, following the chronological order, in which they will serve as the basis for the construction of the harmonization proposal.

2.1 EUROPEANA DATA MODEL (EDM)

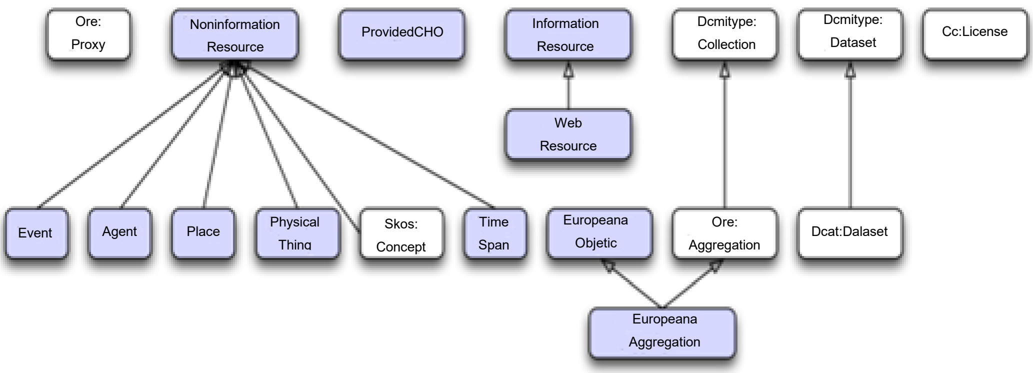
The EDM was created with the proposal to integrate and connect the contents related to the cultural heritage of Europe using the Linked Data principles applied to the Semantic Web.

In this perspective, "[...] the idea is to organize metadata from different domains and make it available in a single digital environment to reach a wider audience" (SILVA; SEGUNDO; FREIRE, 2020, p. 19). Thus, any elements available in the description of the content, such as classes or properties, are considered (EUROPEANA, 2017).

To this end, according to Europeana (2017), such elements may be inserted in two categories. The first refers to the elements reused from other namespaces, while the second concerns the elements inserted by the EDM model.

The EDM seeks to support the representation of complex objects or objects that have a hierarchical structure, such as files and book parts, among other possibilities (PATRÍCIO, 2012). From this perspective, Figure 2 exposes the classes of the EDM model hierarchically.

Figure 2 – Hierarchy of the EDM classes.



Source: *Europeana* (2017, p. 7).

Figure 2 shows the EDM classes, highlighted by purple rectangles, and the classes stemming from other standards, represented by white rectangles. Hence, the links determined by the EDM may relate to existing elements or even reuse internationally recognized vocabularies (TRIQUES; ARAKAKI, 2020). Patrício (2012) highlighted that the EDM elements have classes and properties used in other schemes, such as the Open Archives Object Reuse and Exchange (OAI-ORE), Dublin Core, and SKOS.

Regarding the description of the entities and metadata of the EDM model, Patrício (2012) showed that its construction is substantiated by the Open Archives Initiative Object Reuse and Exchange (OAI-ORE) model. This action was necessary to integrate the various data models related to cultural heritage and enable the sharing of these data on the Web.

Therefore, given the above, it is observed that the construction of the EDM model was based on other existing models. In addition, its classes are structured hierarchically, and their metadata may be retrieved from the Web.

2.2 *IFLA LIBRARY REFERENCE MODEL (IFLA LRM)*

The *IFLA LRM* is a conceptual model with a high level of generalization structured from the Extended Entity-Relationship (EER) model. Explaining the general principles governing bibliographic information, the IFLA LRM aims to provide guidance and a basis for the formulation of cataloging rules and implementation of bibliographic systems (RIVA; LE BOUEF; ŽUMER, 2017).

Designed as a consolidation of the three models of the FR family, the IFLA LRM was developed from the confrontation of the definitions of the entities, attributes, and relationships of the models of the FR family, from which the elements of these models were semantically aligned and generalized (RIVA; LE BOUEF; ŽUMER, 2017). However, unlike the models of the FR family, the IFLA LRM presents a hierarchical structure in which entities are modeled as subordinate classes between superclasses and subclasses. This structure is expressed through the relationship "isA" in formal modeling and implies that attributes and relationships declared at a higher level do not need to be repeated in all subclasses, allowing the inheritance of attributes (Zumer, 2018, p. 312).

Chart 1 – Hierarchy of the entities

Higher Level	Secondary Level	Tertiary Level
LRM-E1 Res	--	--
--	LRM-E2 Piece of Work	--
--	LRM-E3 Expression	--
--	LRM-E4 Manifestation	--
--	LRM-E5 Item	--

--	LRM-E6 Agent	--
--	--	LRM-E7 Person
--	--	LRM-E8 Collective Agent
--	LRM-E9 Nomen	--
--	LRM-E10 Place	--
--	LRM-E11 Period of Time	--

Source: Riva, Le Bouef, and Žumer (2017, p. 19).

According to Chart 1, the IFLA LRM declares a higher-level entity called *Res* ("thing" in Latin) defined as "Any entity in the universe of discourse" (RIVA; LEBOEUF; ŽUMER, 2017, p. 21). Thus, it includes both physical things and concepts, and all other entities are directly or indirectly subclasses of this entity.

Regarding the attributes, given that the model proposes to address all types of bibliographic materials, the IFLA LRM includes only the most frequent and general attributes (ŽUMER, 2018). None of the attributes are necessarily required for any instance of an entity, and they must be assigned according to the level of granularity and relevance to its implementation.

Moreover, the relationships, as proposed by the model, are indicated in an abstract and general manner, providing context to the instances of the entities (RIVA; LE BOEUF; ŽUMER, 2017).

2.3 *BIBFRAME*

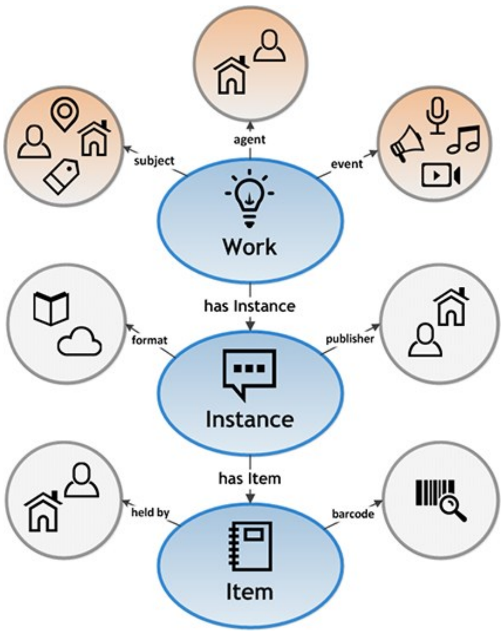
The BIBFRAME initiative was developed with the intention of succeeding the Machine-Readable Cataloging (MARC) format, which, in turn, was created to enable the electronic sharing of cataloging information (LIBRARY OF CONGRESS, 2012). Thus, due to this possibility, the bibliographic resource may be described only once and shared among catalogers, thus reducing the rework in its elaboration process.

The Library of Congress (2012) considers that the BIBFRAME is a model designed for the future of bibliographic description through the search for its application in the Web environment. In addition, such a model was designed with the purpose of integrating the information community and meeting the specific needs of its users. For such, these objectives are achieved through the differentiation between the conceptual content and its physical manifestations, just as it identifies the entities and exposes their possible relationships.

As for the structure, the BIBFRAME was influenced by the Functional Requirements for Bibliographic Records (FRBR) as it relates to entities, attributes, and relationships between entities. Likewise, the new model considers the structure of the Resource Description Framework (RDF) to identify the metadata and vocabularies implemented in Web resources. In addition, the *BIBFRAME* is also based on the *Resource Description and Access* (RDA), which prescribes, according to Oliveira and Castro (2022, p. 2), "[...] a set of data elements, guidelines, and instructions for creating structured metadata according to international user-focused models".

The RDF classes and properties form the BIBFRAME vocabulary. In mid-2016, a new version of its vocabulary was published, entitled BIBFRAME 2.0 (LIBRARY OF CONGRESS, 2016). According to Silva (2022, p. 34), "BIBFRAME 2.0 has, to date, a total of 209 properties and subproperties and 193 classes and subclasses. With this, the sum results in 402 elements in its vocabulary". From this perspective, Figure 3 presents the three main classes in their different levels of abstraction.

Figure 3 – Model BIBFRAME 2.0



Source: *Library of Congress* (2016).

Given the above, the BIBFRAME consists of the following main classes: Piece of Work, Instance, and Item. This way, the first class refers to the highest level of abstraction, representing the conceptual essence of the cataloged resource, such as authors, subjects, and language. In turn, the second class corresponds to the information on a specific piece of work, such as format, place, and date of publication. Finally, the third class involves information regarding the location of the item, which may be physical or virtual (LIBRARY of CONGRESS, 2016).

In addition, the orange circles in Figure 3 represent the following key concepts: agents, subjects, and events. Hence, the agents correspond to the authors, editors, and illustrators, among other people related to the piece of work or instance. The subjects indicate the concepts addressed in the Piece of Work, while the events allude to the content of a given Piece of Work (LIBRARY OF CONGRESS, 2016).

In summary, the BIBFRAME structure was verified, composed of classes, subclasses, properties, and subproperties organized at different levels of abstraction. Another outstanding feature refers to the possibility of sharing metadata on the Web, which may contribute to a more agile performance of the activities of a cataloger.

3 METHODOLOGY

This research adopted as its method the process of harmonization of conceptual models, which consists of the systematic mapping of the semantic equivalence between elements of different metadata standards with the purpose of enabling interoperability between systems that use them. This mapping is used to "[...] convert metadata descriptions represented by a source vocabulary to a target vocabulary" (TANIGUCHI, 2018, p. 428).

Pierre et al. (1999, p. 74) conceptualized harmonization as a step in the Crosswalk method, which consists of extracting properties, processes, and the organization used by the various metadata standards, enabling a generic structure for new standards or updating existing standards. In turn, Arakaki (2019) established harmonization with four substeps, as per Chart 2.

Chart 2 – Harmonization substeps

Substep	Observation
Terminology	Using terminologies that differ from the standards hinders the mapping between them.
	It is essential to agree on the terminology of the standards and establish a formal definition for each term.
Properties – The similarities of the properties of the standards are extracted, and the concepts generalized.	Unique identifiers for each metadata, e.g., tag, label, identifier.
	What is the semantic definition of each piece of metadata?
	Is the metadata mandatory, optional, or required under specific conditions?
	May a metadatum occur multiple times?
	Organization of metadata relative to each other, e.g., hierarchical relationships.
	Constraints imposed by element values (free text, numeric scale, or date)?
	Optional support for locally defined metadata elements?
Organization	To facilitate, each standard must be organized similarly so that a given section of a standard may be found in a section of another.
Process	There are times when the choice of the selected process is arbitrary and not a process analogous to another related standard.

Source: Arakaki (2019, p. 25).

Hence, the harmonization procedures adopted were based on Pierre et al. (1999), Taniguchi (2018), Arakaki (2019), and Carrasco (2019), thus limited only to the entities of the models. The following steps were performed: (i) terminological-conceptual mapping; (ii) entity categorization; and (iii) entity correspondences. In the terminological-conceptual mapping, the entities of the IFLA LRM, EDM, and BIBFRAME conceptual models were identified, along with their respective definitions. In turn, in the entity categorization step, the entities were categorized from their descriptive functions. Finally, in the entity correspondence step, based on the comparison of the results of the previous steps, we sought the equivalence of the entities of the conceptual models.

4 TERMINOLOGICAL-CONCEPTUAL MAPPING OF THE HARMONIZATION PROCESS

In this first step, the main entities of the models and their respective definitions were identified. This identification occurred primarily from the documents or declarations of the models.

Chart 3 – EDM entities

EDM	
Main Entities	**Definition**
edm:ProvidedCHO	Class of objects of cultural heritage.
edm:WebResource	Informational resources with Web and URI representation.
ore:Agreggation	Set of related resources, such that the set may be treated as a single resource.
Contextual Entities	**Definition**
edm:Agent	Class of persons or group of persons who perform intentional acts for which they may be considered responsible
edm:Place	Space Extension. Location.
edm:TimeSpan	Class of temporal periods with beginning, end, and duration.
skos:Concept	Idea or unit of thought established in an information organization system that describes its conceptual structure

Source: Europeana (2017).

The three main classes of EDM are edm:ProvidedCHO, edm:WebResource, and edm:Aggregation. These classes have as their referents, respectively, the cultural heritage object itself, its digital representation, and the set of resources related to the cultural heritage object. Thus, any resource described based on the model must necessarily have a record of these classes and their metadata properties (EUROPEANA, 2017).

Contextual entities, in turn, are modeled separately from EDM:ProvidedCHO – a class that has primacy among the main entities – and provide additional metadata (from thesauri and controlled vocabularies) to the cultural heritage object itself (EUROPEANA, 2017).

Chart 4 – IFLA LRM entities

IFLA LRM	
Entities	**Definition**
Res	Any entity in the universe of discourse.
Piece of Work	Intellectual content of a specific creation.
Expression	Specific combination of signals that convey intellectual or artistic content.
Manifestation	Set of all supports that are supposed to share the same characteristics of intellectual or artistic content and aspects of physical form.
Item	Object carrying signals intended to convey intellectual or artistic content.
Agent	Entity capable of deliberate actions, assigning rights, and being held accountable for its actions.
Person	An individual human being.
Collective Agent	Gathering or organization of people with a specific name and capable of acting as a unit.
Nomen	Association between an entity and a designation that refers to it.
Place	A given space extension.
Time interval	Time extension with a beginning, an end, and a duration.

Source: Adapted from Riva, Le Bouef, and Žumer (2017).

The IFLA LRM has the entities of Piece of Work, Expression, Manifestation, and Item as its structural core. However, as the model is of a high level of abstraction and generalization, there is flexibility, in addition to extension mechanisms, for implementations of its structure in information systems:

> Although the structural relationships between the entities of piece of work, expression, manifestation, and item are essential for the model, the attributes and other relationships declared in the model are not essential for implementation (RIVA; LE BOUEF; ŽUMER, 2017, p. 10).

From this core, the IFLA LRM demonstrates an emphasis on the modeling of intellectual content and the grouping of its instances, whereas the entities of the EDM emphasize the cultural heritage object itself. This emphasis of the IFLA LRM justifies its abstract approach to the entities Piece of Work, Expression, and Manifestation in such a way that only the Item entity has as a referent a concrete unit.

Chart 5 – BIBFRAME entities

BIBFRAME	
Entities	**Definition**
Piece of Work	Conceptual essence of the resource.
Instance	Individual and material incorporation of the Piece of Work.
Item	Physical or electronic copy of the Instance.
Agent	People, organizations, jurisdictions, etc., associated with the resource.
Subject	Concepts that contextualize "about" what the Piece of Work is.
Event	Occurrences whose record is the content of the Piece of Work.

Source: Prepared by the authors (2023).

Because they are inserted and based on the Anglo-American cataloging tradition, the BIBFRAME entities have a terminological affinity with the IFLA LRM. The BIBFRAME models both the intellectual content and its instances through its entities, structuring them from the RDF trebles (SEIKEL; STEELE, 2020).

4.1 ENTITY CATEGORIZATION

The entities of the EDM, IFLA LRM, and BIBFRAME models were analyzed from their definitions, functions, attributes, and relationships. This analysis resulted in the establishment of seven categories, within which all entities may be mapped.

Chart 6 – Entity categorization

Category	Description
Intellectual Content	Description of sets of conceptual objects.
Subject	Description that contextualizes the conceptual structure of the resource within the information organization system.
Concrete Unit	Description of the resource that conveys intellectual content.
Agent	Description of individuals or groups who have some responsibility for the resource.
Space-Time	Description of a time extension with start, end, and duration or a geographic space extension that contextualizes the resource.

Reification	Description that formalizes a relationship as a distinct entity with its own attributes and properties.

Source: Prepared by the authors (2023).

The Intellectual Content category encompasses abstract entities that are sets of other entities, i.e., whose function within the models is to group other entities from their intellectual content. This category has a higher occurrence in the IFLA LRM and BIBFRAME models. Of a similar purpose, the Subject category also encompasses entities that are sets; however, its function is to group other entities based on their intellectual context.

The Concrete Unit category refers to entities that have singular instances of the informational object itself as their referents and not sets. Likewise, the other entities, Agent, Period of Time, Place, and Reification, have as their primary functions the description and contextualization of the entities of the Concrete Unit category.

A particularity, however, to be noted in the Reification category is that it indicates entities that may be understood through the "process by which a relationship is modeled as an entity so that it may have its own attributes and relationships" (RIVA; LE BOEUF; ŽUMER, 2017, p. 105).

4.2 ENTITY CORRESPONDENCE

From the previous steps of the identification and categorization of entities, the comparison of the entities occurred to verify functional and semantic equivalences between the entities.

Chart 7 – Equivalence of entities from the Intellectual Content category

Intellectual Content		
IFLA LRM	**EDM**	**BIBFRAME**
Piece of Work	-	Piece of Work
Expression	-	-
Manifestation	-	Instance

Source: Prepared by the authors (2023).

As established in the entity categorization, this category integrates abstract entities that are sets that structure the concrete entities Item of the IFLA LRM and the BIBFRAME models. There is a strong terminological agreement between the IFLA LRM and BIBFRAME entities; however, structurally and functionally, the Piece of Work and Expression entities of the IFLA LRM are condensed into a single entity in the BIBFRAME, which is its Piece of Work entity.

Such condensation is clearly seen in the fact that, in the IFLA LRM, language is an attribute of the Expression entity, with the Piece of Work entity having the more abstract function of grouping instances that share the same intellectual content regardless of language; in contrast, in the BIBFRAME, language is an attribute of the Piece of Work.

Concerning the Manifestation and Instance entities, there is a closer equivalence than the previous entities. In both models (*IFLA LRM* and *BIBFRAME*), these entities are sets " [...] of all supports that supposedly share the same characteristics of intellectual or artistic content and aspects of physical form" (RIVA; LE BOEUF; ŽUMER, 2017, p. 26).

Likewise, as previously verified, since the EDM model gives primacy to the edm:ProvidedCHO entity, which consists of the concrete object itself, it lacks the level of abstraction necessary for structuring the intellectual content modeling, depending on this requirement of the skos:Concept entity.

Table 8 – Equivalence of entities from the Subject category

Subject		
IFLA LRM	**EDM**	**BIBFRAME**
Res	skos:Concept	Subject
-	-	Event

Source: Prepared by the authors (2023).

In the Subject category, the three models have equivalent entities, despite some functional transcendence in the case of the Res entity of the IFLA LRM. The Res entity has the functionality to indicate the subject due to its derivation from the Thelma entity of the Functional Requirements for Subject Authority Data (FRSAD) and the relationship LRM-R12 'PIECE OF WORK has as RES as a subject'; however, this entity also has the functionality to enable extension mechanisms of the IFLA LRM and to give ontological consistency to the model, so that any entity of the IFLA LRM (Piece of Work, Expression, Manifestation, etc.) is a Res, and, in being a Res, at power, a subject, and as a subject it may relate to other subjects, i.e., other Res entities.

Likewise, the BIBFRAME declares as an entity with functionality to indicate 'about what' a Piece of Work is, the Event entity, performing in the subject category a dichotomy between a subject as domains of knowledge and a subject as a historical occurrence.

Chart 9 – Equivalence of entities from the Concrete Unit category

Concrete Unit		
IFLA LRM	**EDM**	**BIBFRAME**
Item	edm:ProvidedCHO	Item
-	edm:WebResource	-

Source: Prepared by the authors (2023).

The Concrete Unit category contains the 'concrete entities' of the three models, which necessarily have singular referents, not being defined as set entities. There is a terminological and functional equivalence between the entities; however, structurally, the EDM model makes a distinction between the object itself and its digital representation through the entities edm:ProvidedCHO and edm:WebResource. The IFLA LRM brings this distinction at the abstract level by conferring the attribute Representative Expression at the Piece of Work level, which indicates canonicity of a given Expression, Manifestation, or Item over other instances of these entities, whose characteristics "[...] are easily identified as those depicted in the initial or original expression of the piece of work, which in turn is materialized in the first manifestation of the piece of work" (RIVA; LE BOEUF; ŽUMER, 2017, p. 93).

Chart 10 – Equivalence of entities from the Agent category

Agent		
IFLA LRM	**EDM**	**BIBFRAME**
Agent	edm:Agent	Agent
Person	-	-
Collective Agent	-	-

Source: Prepared by the authors (2023).

The entities of the Agent category, according to Chart 10, have, in addition to functional equivalence, terminological agreement. The decision of the IFLA LRM to declare the Person and Collective Agent entities as subclasses does not change the semantics of the Agent entity and its equivalence with entities of the other models. The main functionality of these entities is to provide descriptions and group instances over which the Agent entity has some responsibility.

Chart 11 – Equivalence of entities from the Period of Time category

Space-Time		
IFLA LRM	**EDM**	**BIBFRAME**
Time interval	edm:TimeSpan	-
Place	edm:Place	-

Source: Prepared by the authors (2023).

The IFLA LRM and EDM entities included in the Period of Time category have strict terminological and functional equivalence. They are intended to provide geographical and temporal descriptions that contextualize the informational object, whether this description is characterized as a creation date, place of publication, etc.

Chart 12 – Equivalence of entities from the Reification category

Reification		
IFLA LRM	**EDM**	**BIBFRAME**
Nomen	ore:Agreggation	-

Source: Prepared by the authors (2023).

The placement of the Nomen and ore:Aggregation entities in the Reification categorization and the equivalence between these entities are proven primarily by their respective functionalities within their models and their attributes or properties. Both entities establish connections between them themselves and their identifiers, data providers.

5 FINAL CONSIDERATIONS

From the harmonization of the entities of the IFLA LRM, EDM, and BIBFRAME models, this article sought to ascertain a potential interoperability between the entities of the models. For such, the following steps were performed: (i) terminological-conceptual mapping; (ii) entity categorization; and (iii) entity correspondences.

It was found that the most notable difference between the models is expressed in the Intellectual Content category, which encompasses entities modeled for the description of the intellectual content of the resource. Because they are models from the bibliographic universe substantiated by cataloging tradition, the IFLA LRM and BIBFRAME models have entities that are functionally equivalent in this category, while the EDM, as a model that gives primacy to the cultural heritage object itself, does not have any entities that may be mapped in this category.

Likewise, se stress that, in the Concrete Unit category, despite the terminological and functional equivalence between the entities, structurally, the EDM model makes a distinction between the object itself and its digital representation through the entities edm:ProvidedCHO and edm:WebResource. In the IFLA LRM and BIBFRAME models, such a distinction occurs between abstract entities in the Intellectual Content category, which allows both in the Concrete Unit category to declare only the Item entity. In the other categories, consistent equivalence was observed between the entities, their functionalities, and terminologies.

Thus, the harmonization carried out in this study aims to foster discussions on the interoperability of the EDM, IFLA LRM, and BIBFRAME models and serve as an initiative for a complete crosswalk between models.

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