Enhancing Expressiveness of Conceptual Modeling for Bibliographic Relationships:

A Reflection on the FRBR Entity-Relationship Model

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초 록

서지관계모형을 위한 개념적 모델인 IFLA의 FRBR (Functional Requirements for Bibliographic Records)에 대한 대안적인 접근이 발표되어 왔지만, FRBR 모델의 내부적인 일관성에 대해서는 많은 연구가 진행되어 있지 않은 실정이다. 본 연구는 FRBR 객체-관계 (entity-relationship) 모델에서 객체들 (entities)간의 관계 (relationships) 에서 발생하는 상속 (inheritance) 속성과 관련된 모델의 내부적 모순점을 지적하며, 이러한 문제를 해결하기위해 FRBR 모델의 표현성 (expressiveness)을 강화하기 위한 여러 대안적인 방안을 논의한다.

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Abstract

The Functional Requirements for Bibliographic Records (FRBR) is a "conceptual model of the bibliographic universe" developed by the International Federation of Library Associations and Institutions (IFLA). Although some studies have suggested improvements in FRBR, and others explore alternative approaches, less attention has been paid to analyzing the internal coherence and consistency of the FRBR view as presented not only in the FRBR entity-relationship model and text of the FRBR document, but also in the related explanations and presentations of FRBR expositors. Our investigations have noted some interesting discrepancies between the general FRBR approach as presented in various expository documents and the specific account presented in the FRBR ER model and the FRBR document. We see that in one case these discrepancies can be easily remedied by adding additional modeling constructs and assertions, but in another case (the supposed "inheritance" of attributes across the Group 1 entities), there is a substantial difficulty in maintaining a consistent model. We discuss several alternative approaches to enhancing the expressiveness of FRBR in order remedy this problem. We note that none is entirely satisfactory.

키워드: 상속, 개념적 모델, 표현성, 서지관계, FRBR(Functional Requirements for Bibliographic Records), Inheritance, Conceptual Modeling, Expressiveness, Bibliographic Relationship

1. Introduction

The Functional Requirements for Bibliographic Records(FRBR) is a “conceptual model of the bibliographic universe” developed by the International Federation of Library Association and Institution(IFLA) to provide a generalized view of bibliographic entities and relationships(IFLA Study Group on the Functional Requirements for Bibliographic Records 1998). FRBR is intended to guide both the development of software systems and cataloguing practice and has been extremely influential: international bibliographic databases and software systems are being "FRBRized", and the new revision of the AACR Anglo-American Cataloging Rules will reflect the FRBR framework(Joint Steering Committee for Revision of AACR). Moreover, although designed primarily to support the library community, FRBR is increasingly recognized as one of the most sophisticated and empirically grounded frameworks for intellectual material in general and is increasingly influential in other domains requiring ontologies for content management.

Although refinements have been proposed and some alternative models discussed, there has been little published analysis of adequacy of the explicit FRBR model to the broader understanding of the FRBR approach as expressed various expository accounts. In what follows we show that there are some interesting variations between FRBR's formal model and the narrative expositions of FRBR's authors and explicators, that is, between the formal model and the framework as more broadly understood by the cataloguing community. We see that in one case these discrepancies can be remedied by adding additional modeling constructs and assertions. In another case(the supposed “inheritance” of attributes across the Group 1 entities), there is a substantial difficulty in maintaining a consistent model. We discuss several alternative approaches to enhancing the expressiveness of FRBR in order remedy this

problem, but note that none is entirely satisfactory.

The present paper is an introduction to the problem of adapting the expressiveness of the FRBR formal model to the common broader understanding of the FRBR approach, articulating the nature of the problem and exploring the landscape of options and tradeoffs. Elsewhere we have taken up the particular issue of inheritance in FRBR in greater detail. (Renear and Choi 2006).

2. FRBR

FRBR divides bibliographic entities into three groups: Group 1(the products of intellectual and artistic endeavor), Group 2(their creators), and Group 3(their subjects). We are concerned here only with the FRBR Group 1 entities: work("a distinct intellectual or artistic creation"), expression("the intellectual or artistic realization of a work"), manifestation("the physical embodiment of an expression of a work"), and item("a single exemplar of a manifestation") (IFLA Study Group on the Functional Requirements for Bibliographic Records 1998).

As described in the introduction FRBR recognizes four sets of Group 1 entities.

Entity	FRBR characterization	Possible Synonyms (Tillett, 2003b)
Work	A distinct intellectual or artistic creation	conceptual content, story, ideas
Expression	The intellectual or artistic realization of a work in the form of alphanumeric, musical, or choreographic notation, sound, image, object, movement, etc., or any combination of such forms	particular text of edition in a special language
Manifestation	The physical embodiment of an expression of a work	publication
Item	A single exemplar of a manifestation	copy

Figure 1: The FRBR Group 1 Entities

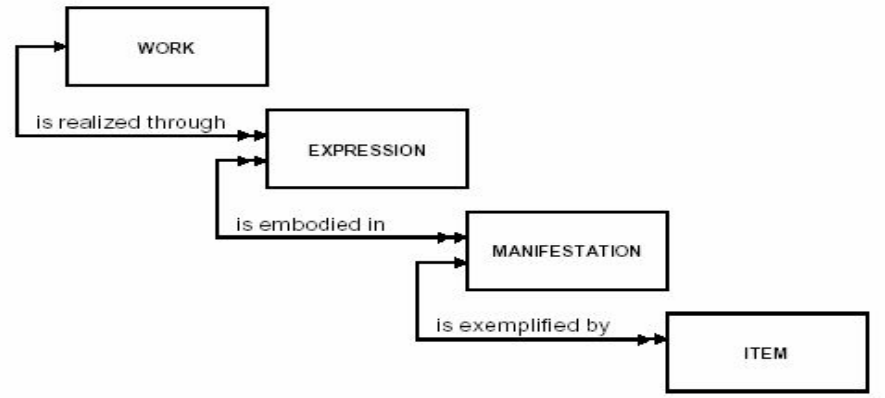

Figure 2: ER Diagram of FRBR Group 1 Entities and Primary Relationships (diagram from IFLA, 1998)

3. Unmodeled But Implicit Bibliographic Relationships in FRBR

We discuss two cases of implicit but unmodeled bibliographic relationships in FRBR.

3.1 Disjointness

Although it is not explicitly asserted in the ER diagram or in the text of the FRBR document it is nevertheless evident that the four Group 1 entity sets are thought of has having no members in common. A close examination of the prose definitions makes it clear why this is so: works are intellectual achievements independent of their symbolic representations, expressions are specific symbolic realizations of works, manifestations are the kinds of physical objects or events that embody such symbolic representations, and items are concrete physical objects Clearly these are conceptualized as disjoint sets. However, the ER diagram provided in the FRBR document does not in any way assert or model this disjointness.

3.2 Inheritance

In presenting FRBR researchers and practitioners use routinely use expressions such as “hierarchy” and “inheritance”, and describe entities at “lower levels” of the

Group 1 entity “hierarchy” as “inheriting” the characteristics of their corresponding entities at higher levels. For example,

Vellucci refers to "hierarchical levels" between Group 1 entities, "each of which incorporates the attributes of its superordinate entity"(Vellucci 1997).

Oliver says “the characteristics of the work belong to all expressions, all manifestations, and all items[…] characteristics(or attributes) are inherited by all lower levels of the hierarchy”(Oliver 2003).

Tillett speaks of Group 1 entities as forming a “hierarchy”(Tillett 2002, Tillett 2003) and of properties as being “inherited” saying in one place: “a characteristic of a work is carried to all the entities below it in the hierarchy through a transitive relationship”(Tillett 2003).

A natural interpretation of such remarks is this: If Herman Melville is the author of the work Moby Dick, then he is the author of the specific expression(text) that someone reads, the manifestation(edition) they choose to seek out, and the item(physical book) that they purchase; if the text is inEnglish, then so is the edition, and so is the physical book; if the edition is in the Century Schoolbook typeface then so is the physical book; and so on. However although this is commonly thought to be the case, as shown above, there is nothing in the FRBR ER model or the FRBR text that explicitly implies any such inheritance of properties. case, as shown above, there is nothing in the FRBR ER model or the FRBR text that explicitly implies any such inheritance of properties.

4. EER for Modeling Unmodeled Relationships in FRBR

We have seen that there are relationships implicit in the FRBR view that are not explicitly modeled in the FRBR conceptual model, namely disjointness of the Group 1 entity sets and inheritance across the Group 1 entity sets. Could this discrepancy be remedied by simply adding the missing assertions to the FRBR ER model

and documenting them in the text of the FRBR document? In fact this is not possible: the specific modeling framework being used by FRBR, namely entity-relationship modeling, does not have constructs for representing either entity set disjointness, or attribute inheritance.

However, there is an enhancement to Entity-Relationship modeling(EER), known as "Extended Entity-Relationship modeling", which does support the modeling of both disjointness and at least one variety of inheritance

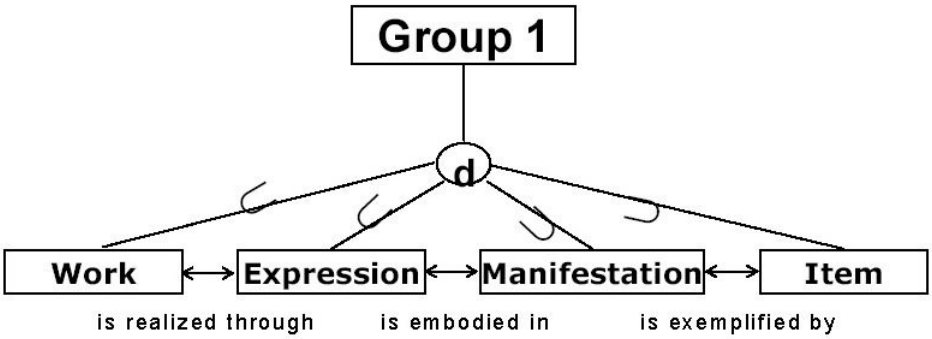

Figure 3: Modeling disjoint relationships with EER

(Renear and Choi 2006). In this section we consider how EER can be used to model the unmodeled relationships. However, we will also show that although the EER construct for class disjointness appears to adequately model the implied disjointness of the four Group 1 entity sets, the EER constructs for inheritance through sub-class specification/generalization does not appear to be appropriate for the kind of inheritance believed to be exhibited by the FRBR Group 1 entities.

4.1 Disjointness

In EER modeling there are graphic symbols for representing subclass relationships among entity classes, and the disjointness of subclasses. The modeling the missing relationship of disjointness relationship is quite simple as illustrated in Figure 3. The meaning of this symbolism that the

four classes Work, Expression, Manifestation, Item are disjoint subclasses of the set of Group 1 Entities. (However, we do note a possible ambiguity in understanding "Group 1 Entities" as either a set of entities or a set of entity *types*:our reading here is the former.)

Although simple to represent such an addition should not be considered merely a matter of notation. The adoption of a more expressive modeling language is always a potentially significant change in a conceptual model and often has consequences for computational efficiency and interoperability.

4.2 Inheritance

The next problem is the representation of implicit but unmodeled relationship of *inheritance*. In the knowledge representation community inheritance is a feature of so-called "subsumption hierarchies". Subsumption hierarchies are typically understood in one of two alternative ways: as structures of set/subset relationships, or as structures of logical implication. We can express these relationships in first order logic as an implication involving predicates(e.g. "for all x if x is a dog then x is a mammal) or as a set/subset relationship between sets(e.g. "the set of mammals is a subset of the set of dogs").

Given a subsumption hierarchy the complete inheritance of all properties "down" the hierarchy follows immediately from logic(or, alternatively, set theory) alone. If anything that is a dog is a mammal(or, alternatively, the set of dogs is a subset of the set of mammals), then any property had by all mammals is also had by all dogs.

EER, unlike ER, does indeed let us define subclass/superclass hierarchies that will support the inheritance relationships noted in previous section, but it hard to see how we can exploit this construct in a way that is consistent with fundamental aspects of the FRBR model to model the inheritance intended by the authors mentioned above. For instance, a subsumption

style inheritance from work *MobyDick* to expressions realizing that work would require that expressions realizing MobyDick be members of the class of works MobyDick. This departs from the FRBR model is several ways, first in allowing there to be numerically distinct works what are all *MobyDick*, and second in requiring one and the same thing to be both an expression and a work, contradicting the disjointness requirement. So it is hard to see how inheritance could be accommodated in an EER in a subclass/super class hierarchy.

Were we wrong in our previous assumption of disjointness? Certainly not, for the reasons given above: it is clearly not the case that for FRBR each individual instance of, say, an expression, is also a work. And yet at the same time there is no way to avoid the fact that the common perception of the FRBR model is that it implies a "transitive relationship" that supports attribute inheritance.

The solution to this apparent paradox is to conclude that the intended inheritance is not the unlimited general inheritance that would be supported by a class hierarchy, where as a matter logic(or set theory) alone all attributes of all instances of a superclass are inherited by the instances of the subclass, but rather a limited inheritance that is defined in terms of specified relationships(other than subsumption) holding between entity classes and limited to particular attributes and/or attribute values.

However, how exactly can this be done? This interesting problem, which we first introduced in Renear and Choi(2005), has received little attention, although it has been foreshadowed in a brief comment by Manzanos(2003) and perhaps also by some very insightful remarks by Taniguchi(2002).

5. Candidate Solutions to the Problem of Inheritance

We now discuss possible strategies for accommodating

inheritance in FRBR. These strategies nicely illustrate the sort of options typically available for resolving difficulties of this sort.

5.1 Strategy 1: Re-Expressing FRBR in Set-Theoretic Terms

Carlyle(2004) points out that there are advantages to conceptualizing Group 1 entities as sets of similar items rather than abstract objects. Such a "set theoretic" approach to bibliographic entities was earlier developed in detail in Svenonius(2001) as an operational complement to conceptual models. On this sort of account the only entity type is Item; there are no abstract entities such as Work, Expression, or Manifestation. Rather a hierarchy of entity classes is formed based on similarity, which corresponds to the respective abstract entity type.

For instance, all of the copies of Moby Dick would be considered members of a particular Work Set. That Work Set would be partitioned into Expression Sets, each composed of textually identical items. Each Expression Set would be partitioned into Manifestation Sets, sets of textually identical items that are also similar with respect to typography, materials, and other manifestation level attributes. Notice that this framework allows us to avoid talking about Manifestations, Expressions, and Works as if they were entities or objects. So instead of saying an item I_v exemplifies a Manifestation M which embodies an Expression E, we say a we say a copy C_w is a member of Expression Set ES_x; and instead of saying embodies an Expression E we say every copy which is a member of Manifestation Set MS is a member of Expression Set ES. The association of items into their sets is specified with reference to a particular kind of similarity rather than a relationship with an abstract object. For instance, copies which are textually similar are placed in the same Expression Set.

This approach to the bibliographic universe does indeed deliver the desired inheritance; any property that is had by every member of a Work Set will be held by any

member of a Manifestation Set which is a subset of that Work Set. This is just a matter of simple logic.

There are two obvious problems with this approach. The first is simply that it is a radically different view of the bibliographic universe than that presented by FRBR. We might say that it is a "nominalist" view(only concrete particular objects) whereas FRBR presents a realist view(abstract as well as concrete objects). The second is problem is that it is at least debatable whether concrete objects like physical copies really do have, strictly speaking, properties like being "in English" or "in Helvetica".

[In philosophy this sort similarity-based set-theoretic approach to defining concepts is a well-known strategy for attempting to avoid commitment to abstract objects. Whether succeeds in this or not is continues to be a mater of debate.]

5.2 Strategy 2: Define Limited Inheritance in First Order Logic

In an entity relationship modeling there is no general expectation that inheritance will occur across arbitrary relationships, so if

D1: F is *inherited with respect to* R =df $(\forall x)(\forall y)[Rxy$

inheritance is desired it must be in some way explicitly specified. Given the general nature of entity relationship modeling(distinct entity types each with an appropriate attribute set) any inheritance will be limited to certain attributes and not others. If FRBR does wish to incorporate inheritance into its framework it must articulate rules for limited inheritance. In what follows we explore a little how this might be done, but end inconclusively(see also Renear and Choi, 2005, Renear and Choi 2006).

Inheritance may be described in general as one entity receiving "properties or characteristics of another, normally as a result of some special relationship between the giver and receiver"(Danforth and Tomlinson 1988, cited by Taivalsaari 1996). A first attempt at identifying the general form of an inheritance rule might be(See

D1):

This says that a particular property F is inherited with respect to a relation R whenever it is the case that if something bears R to something else, then if the first thing is F then the second is also. So *is blue*(F) inherits with respect to *has as apart*(R). Because if something is part of a blue thing then it is itself a blue thing. A bibliographic example might be: *being in English* is inherited with respect to *embodies*.

A bibliographic example might be: *being in English* is inherited with respect to *embodies*. One may also define inheritance not for individual determinate properties, but for general determinable attributes combined with their values(See D2):

D2: Amz is inherited with respect to R $=_{df} (\forall x)(\forall y)(\forall z)[(Rxy \supset (Axz \supset Ayz)]$

Here A is a two place predicate representing a determinable attribute such a has the color and z ranges over possible colors, such as blue, understood as individuals, not predicates. Colloquially the application to the color example would be: the color of a thing is inherited by its parts. The bibliographic example here might be: the language of a manifestation is inherited from the expression the manifestation embodies. Note the additional generality over D1. This approach has some promise, but it would be difficult to develop in sufficient detail and some care is necessary to avoid problems of trivial satisfaction.

5.3 Strategy 3: Introduce the Materialization Construct

An additional conceptual modeling construct, materialization, has been proposed in part to address precisely the kind of limited inheritance we wish to recognize here(Pirotte et al 1994, Borgida and Brachman 2003). Roughly, materialization is a relationship between two classes of objects where the first stands in a one-to-many relationship with second and there are specific but limited inheritance relationships are defined in virtue of which the

former objects may be called more abstract" than the latter. Applied to bibliographic entities one would say that works are materialized as expressions which are materialized as manifestations, which are materialized as items. Using specific mechanisms provided by the modeling language the desired limited inheritance relationships may be specified. Materialization may be considered a systematic generalization of the logic-based approach combined with some aspects of the set theoretic approach; it is an interesting strategy which deserves further analysis. Interestingly bibliographic examples are often used to illustrate materialization.

5.4 Strategy 4: Eliminate Inheritance as a Feature of FRBR

Our last candidate solution to the problem of inheritance in FRBR is simply to give up the notion that there really is any genuine inheritance of attributes where the FRBR bibliographic entities are concerned. Perhaps, strictly speaking, an item has a worm hole, but not a typeface, and an edition has a typeface but not, strictly speaking, a language, and so on.

To test your own ontological intuitions, ask yourself this: is it really possible that, strictly speaking, *the very same thing can be both torn* and in English? Or is it rather that physical items are torn, but never, being concrete physical things, in English, and sentences are in English, but never, being abstract linguistic things, torn. On this account to attribute being in a language to a physical object is to commit a "category mistake". We note that the elimination of inheritance does not require us to stop saying things like "this copy is in English", but only that we treat such phrases as idioms, shorthand for "this copy is an item which exemplifies a manifestation which embodies an expression which is in English(Renear and Choi 2005).

5.5 Comparison of the Approaches

If you wish to affirm complete thorough-going inheritance of all

attributes the EER subsumption approach achieves this, but at the cost of a conceptual model that departs radically from the general FRBR view and that may be seen by some as having debatable ontological consequences. The logical approach is promising, but may be difficult to work out in detail and is not easily integrated into traditional ER/EER conceptual modeling. Materialization is also promising and unlike the logical approach coordinated with mainstream conceptual modeling; however it is complicated and still awaits a careful analysis of its ontological commitments and applicability to bibliographic entities. The no-inheritance approach has the advantage of not requiring any changes at all in the FRBR ER model and to some will seem more ontologically accurate — although to those who accept inheritance it obviously has the disadvantage of denying a feature they believe to be real.

In Renear and Choi(2006) the authors of the present article argue in detail for the last approach, that is, we claim that, despite the beliefs of many FRBR expositors, there in fact is no significant attribute inheritance among bibliographic entities and therefore there should be none in FRBR.

6. Conclusion

We have discussed some interesting discrepancies between the general FRBR approach as presented in various expository documents and the specific account presented in the FRBR document. We saw that in one case these discrepancies can be easily remedied by adding additional modeling constructs and assertions, but in another case(the supposed "inheritance" of attributes across the Group 1 entities), there is a substantial difficulty in maintaining a consistent model. We discuss several alternative approaches to extending the expressiveness of FRBR to accommodate inheritance. We found none of these entirely satisfactory. Elsewhere we argue that in fact there is no significant attribute inheritance in the bibliographic universe, and

therefore should be none in FRBR(Renear and Choi 2006).

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