The IFLA Library Reference Model, a step toward the Semantic Web

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Abstract:

The development of the IFLA Library Reference Model (LRM) has occurred in a different technological environment than for the previous IFLA conceptual models of the FR family, FRBR, FRAD, and FRSAD. The usability of data in semantic web applications is now essential. Experience creating IFLA vocabularies for the FR family of conceptual models indicated that a highly structured model definition would make the task of specifying LRM namespaces easier and reduce the potential for ambiguity, making this an integral consideration. The textual model definition is issued with detailed transition mappings clearly indicating the intended alignment of the existing namespaces with the LRM, making LRM linked data ready from the start.

To complete the usability of LRM in the linked data environment, several actions are ongoing or planned. An essential step is the creation of an LRM namespace in the IFLA domain. This will permit encoding linkages with the existing FR namespaces. IFLA LRM is being aligned with other standards, for example, an alignment between the ISBD element set and LRM has been developed by a task group of the ISBD Review Group with a representative of the FRBR Review Group. FRBRoo, the object-oriented definition of the existing FR models compatible with the CIDOC CRM, is being reviewed so as to bring it into conformance with LRM.

Keywords: IFLA Library Reference Model, IFLA LRM, Conceptual Models, FRBR, IFLA namespaces.

1. Developing the IFLA Library Reference Model in a Semantic Web Environment

The IFLA Library Reference Model (IFLA LRM) is the consolidation into a single model of the three separate IFLA conceptual models:

Functional Requirements for Bibliographic Records (FRBR), 1998
Functional Requirements for Authority Data (FRAD), 2009
Functional Requirements for Subject Authority Data (FRSAD), 2010.

Although the idea of consolidating the models into one started being considered almost as soon as FRSAD was published, the first discussions on how to proceed started in fall 2011. In 2012 the FRBR Review Group held a mid-year meeting on consolidation of the user tasks and began discussing the entities, which continued at working meetings at WLIC 2012 in Helsinki. By WLIC 2013 in Singapore, enough conceptual progress had been made for the Review Group to turn its attention to the preparation of a draft document. This task was assigned to the Consolidation Editorial Group (CEG), constituted in 2013.

While sharing the common entity-relationship formalism, the three FR models used very different approaches in their presentation. FRBR relies on free text definitions with no strict boundaries and many examples interspersed throughout the text with no particular explanations; it is somewhat fuzzy and allows for different interpretations of some important concepts. FRAD already attempted a more formal approach, but, particularly for entities, there is no clear distinction between the definition and the scope note; examples often serve as part of the scope note. FRSAD is very simple in structure, so no major issues were encountered there. In addition, both FRBR and FRAD list the relationships somewhat unsystematically.

The semantic web has dramatically changed the technological context in which libraries and library data operate. On one hand it fosters interoperability, but on the other it also requires formal and consistent declarations of the data models. Libraries need to expose their data beyond the limits of their own domain, but also take advantage of and reuse the wealth of information created by others. Collaboration in the heritage sector is a natural development, which requires common understanding of data models. Linked open data is the environment in which we need to operate and for that we need namespaces to represent data elements and controlled vocabularies in a machine-actionable fashion.

Fresh from its experiences in transforming the existing models into namespaces, the FRBR Review Group and the Consolidation Editorial Group was determined to take steps to make the separate process of declaring an IFLA LRM namespace as clear and straightforward as possible. This outlook had a number of consequences in the presentation of the model as a highly structured document.

For all the model elements—the entities, attributes and relationships—the definitions, scope notes and examples are always clearly and separately indicated. All model elements are given a unique ID, making the exact number of defined elements explicit. Entity hierarchies were introduced to allow attributes and relationships to be defined once, at the highest (most general) level appropriate. For entities, any constraints are explicitly given, such as when two entities are disjoint.

ID	Name	Definition	Constraints
LRM-E7	Person	An individual human being	Superclass: *agent* The entities *person* and *collective agent* are disjoint
	Scope notes	The entity *person* is restricted to real persons who live or are assumed to have lived. Strict proof of the existence of a *person* is not required, as long as there is a general acceptance of their probable historicity. However, figures generally considered fictional (for example, Kermit the Frog), literary (for example, Miss Jane Marple) or purely legendary (for example, the wizard Merlin) are not instances of the entity *person*.	

ID	Name	Definition	Constraints
	Examples	{Pythagoras} {Marco Polo} {Homer} {Henry Gray} {Agatha Christie} {Richmond Lattimore} {Robert Fagles} {John I of France, King of France and Navarre} [King from his birth on November 15, 1316 to his death five days later on November 20] {Johann Sebastian Bach} {Raoul Dufy} {the person referred to through the real name 'Charles Dodgson' and the pseudonym 'Lewis Carroll'} [author and mathematician]	

Figure 1. Format of an IFLA LRM entity definition[1]

ID numbers for attributes are assigned subordinately to the entity that the attribute characterizes. The definitions of attributes include the same standard information (definition, scope notes, examples) given for entities.

ID	Entity	Attribute	Definition
LRM-E9-A7	NOMEN	Language	The language in which the *nomen* is attested
	Scope notes		The *language* attribute may be viewed as recording a *scheme* of a particular type (that is, a natural human language) in which a *nomen* may be considered valid. Viewed in this way, the *language* attribute may be implemented as a sub-type of the *scheme* attribute.
	Examples		http://id.loc.gov/vocabulary/iso639-1/zu [*language* Zulu expressed as a URI]

Figure 2. Format of an IFLA LRM attribute definition

The presentation of the relationships also explicitly includes the domain and range, the relationship name and inverse name, and a statement of the cardinality.

ID	Domain	Relationship name	Inverse name	Range	Cardinality
LRM-R11	Item	was modified by	modified	Agent	M to M
	Definition	This relationship links an *item* to an *agent* that made changes to this particular *item* without creating a new *manifestation*			
	Scope notes	Examples include adding annotations, adding an ex-libris, removing pages, rebinding, restoration.			
	Examples	The autograph manuscript of Jean-Paul Sartre's *La nausée was modified by* bookbinder Monique Mathieu			

Figure 3. Format of an IFLA LRM relationship definition

2.   Challenges Creating the FR Namespaces

The FRBR Review Group took its first steps towards bringing the FR family of conceptual models into linked data in 2007 when it launched the Namespaces Project. The report

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[1]   All examples from the 2017-04-16 text of IFLA LRM

Declaring FRBR entities and relationships in RDF,[2] issued in July 2008, stressed the importance of creating namespaces, in an appropriately branded domain, for the FRBR entities, attributes and relationships, and user tasks. Initial work focused on the original entity-relationship definition of FRBR; similar element sets were added for FRAD and FRSAD once these models were published. The tool adopted was the Open Metadata Registry[3] (at that time called the National Science Digital Library (NSDL) Metadata Registry) which allowed sets to be declared first in a "new-proposed" status, allowing for validation by FRBR Review Group members, prior to setting the status to "published".

The four user tasks in each of the three models were declared quite simply as value vocabularies. Element sets were used for the entities, attributes and relationships. For each of the FR models, an element set was created to include the entities (classes) and properties (consisting of attributes and relationships together). The original working group reports served as source documents for the text to appear in the definitions and scope notes, as well as for all information needed to establish the semantics of the classes and properties.

The very style and format of the reports defining the three models presented the first challenge to translating them into namespaces. In a presentation of an entity, where did the definition end and scope notes begin? How much text was properly part of a scope note, rather than being additional text or clarification? In most of the models this was not clear, not having been an issue for the original working groups.

Turning the relationships into properties also presented challenges. Generally, the relationships had not been presented as comprehensive lists in a single format, making it tricky to answer the basic question: How many distinct relationships are there? In FRBR, the "primary" relationships are presented via diagrams in chapter 3 and again in the text of section 5.2, while other relationships between group 1 entities are presented in tables in section 5.3. Although the domains and ranges, relationship names and inverse names are usually easily identified, other important semantic information, such as cardinality of the other relationships, must be deduced. For the FRBR "responsibility" relationships, figure 3.2 shows the range as an unlabelled box around the two entities *person* and *corporate body*. The only way to translate these relationships into namespace entries with a unique domain and range, was to duplicate them: once using the entity *person* as the range, and once using *corporate body*. In the most extreme case, the FRBR subject relationships, presented in figure 3.3, had to be declared separately for each of the ten entities in the FRBR model. In all cases, the definitions of the relationships had to be extracted from the body of the text. In FRAD and FRSAD, relationships are identified only by terms (such as, descriptive relationship, membership, equivalence) so that the relationship names and inverse names had to be inferred.

The presentation of attributes was generally more straightforward. The relevant entity (which serves as the domain of the corresponding property) is clearly and uniquely identified. However, in some cases in FRBR an attribute is qualified by a type of material (such as: Key (Musical Work) or Colour (Image)). The nature of this qualification led to much discussion. Does it serve to provide implicit subclasses of the entities, or did it form part of the scope of the attribute? The conclusion was the second option.

As FRAD and FRSAD build on FRBR, some entities (for example, *work*) did not need to be declared again to be used as the domain or range of FRAD or FRSAD relationships. Many decisions were also needed regarding the naming conventions to be used for properties (providing unique names), and the use of opaque (and thus multilingual) URIs was adopted.

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[2] https://www.ifla.org/files/assets/cataloguing/frbrrg/namespace-report.pdf
[3] http://metadataregistry.org/

The resulting namespaces vary considerably in the number of elements defined, with FRSAD being quite small, and FRBR (entity-relationship definition) being the largest. In the table below the number of elements in the FRBRoo namespace is also given for comparison.

OMR Namespace	Classes	Properties	Total Elements
FRBR(er)	10	206	216
FRAD	12*	138	150
FRSAD	2	17	19
FRBRoo	46	142	188

* In the FRAD namespace 7 classes are taken from the entities explicitly defined in the model (*Family, Corporate Body, Name, Identifier, Controlled Access Point, Rules, Agency*) to which are added the class *Bibliographic Entity* (which is implied in the FRAD high-level diagram) and 4 classes (*Name of a Person, Name of a Family, Name of a Corporate Body, Name of a Work*) extrapolated from the presentation of relationships involving the *Name* entity

3. Transition Mappings

The analysis used in consolidating the three FR models involved preparing tables to more easily compare the definitions of model elements in specific areas. For example, the entities in all three models were compared in one table, in another attributes for the entities *work, expression, manifestation* and *item*, and so on. As the CEG worked through the models in this way, the result of the analysis was recorded in new columns. These working files reveal the outcome of the consolidation process and document the LRM equivalents for all the previously defined model elements. This was seen as valuable information for users of the existing models in understanding the consolidated model, leading to the idea of preparing a companion document to the IFLA LRM model definition consisting of these mappings. This documentation is published as the *Transition Mappings* and was first issued to accompany the world-wide review in 2016[4].

The goal of the *Transition Mappings* is to provide a detailed and authoritative alignment of all the elements from the three FR models to their equivalents in LRM. It is specifically intended to assist anyone transitioning an application of the existing models to LRM.

The mapping tables follow the existing FR namespaces in the OMR and include all the ID numbers, as well as whatever section or table numbering is available from the three reports (according to the level of precision used in each report for each model element). There are sections for user tasks, entities, attributes and relationships. The consolidation outcome is carefully described. An element might have been retained, renamed, redefined, generalized, merged with another, split, deprecated, or deemed out of scope (such as for administrative metadata). In a few cases an attribute is relocated, that is moved from one entity to another. Elements new in LRM, with no precursor in the previous models, are also listed. Additionally, many former attributes are indicated as being "replaced by relationship". This describes the situation in which an LRM relationship involving entities such as *place*, *time-span* or *nomen* was defined, instead of a "date of..." or "place of..." or "term for..." attribute.

4. IFLA LRM Namespace

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4   https://www.ifla.org/files/assets/cataloguing/frbr-lrm/transitionmapping_20160225.pdf

To complete the usability of LRM in the linked data environment, several actions are ongoing or planned. An essential step is the creation of an LRM namespace in the IFLA domain[5]. This will permit encoding linkages with the existing FR namespaces to enable the interoperability of current bibliographic systems with the new, LRM-based ones. We need a persistent, stable and standard solution with the IFLA brand to encourage developers and vendors to design novel bibliographic information systems which adopt IFLA standards and conceptual models. Although the FRBR Review Group has put considerable effort towards achieving this for the existing models, and had implemented a solution which included a dereferencing service in 2012[6], this has not been maintained. We have been waiting too long, but now the excuse that the FR models are not harmonised is not valid.

5.   Alignment with the ISBD Element Set

The first formal alignment being prepared with the IFLA LRM element set is the alignment from the ISBD element set. It is natural and appropriate for another IFLA standard to be the first alignment to be carried out. The ISBD Review Group and its Linked Data Study Group[7] have been actively carrying out alignments and maps using the 2011 consolidated edition of the ISBD. A prerequisite to this activity was to establish and declare the ISBD element set in the Open Metadata Registry. ISBD alignments are maintained with RDA (Resource Description and Access) and the RDA/ONIX framework. In 2016, the alignment from the ISBD element set to the FRBR element set (as declared in the OMR) was completed, replacing the document *Mapping ISBD Elements to FRBR Entity Attributes and Relationships*[8] prepared by Tom Delsey in 2004.

The ISBD Linked Data Study Group planned for the alignment with IFLA LRM during its meeting at WLIC 2016, and the task group was formed in fall 2016. The task group consists of five members from the ISBD Review Group and one member named by the FRBR Review Group to represent the IFLA LRM. The task is to establish the alignment in the direction from ISBD to LRM only. The initial strategy was to work with the 2016 ISBD-FRBR alignment and extend to LRM through the *Transition Mappings* (using the draft dated 2016-02-25 issued for the LRM world-wide review, and subsequent committee drafts). In this way the FRBR column in the alignment would have served as a pivot to link ISBD to LRM.

While this method of procedure allowed many issues to surface and allowed for fruitful discussion, it did not prove to be a satisfactory way of establishing or presenting an ISBD-LRM alignment. Among the issues is that LRM has reformulated many FRBR attributes as relationships. Using alignments from an ISBD element to an LRM relationship is a change from the previous methodology, as the ISBD-FRBR alignment aligned only with attributes of of the *work, expression, manifestation* or *item* entities in FRBR. Alignments to LRM relationships are essential for expressing the concepts implicit in some properties in ISBD areas 7 (Notes) and 8 (Resource identifier and terms of availability). The notes in area 7 include relationships between *works*, particularly serials (linking notes).

Another issue is that LRM is a less granular model than FRBR. Whenever it was possible to generalize, LRM did so, leading frequently to several FRBR attributes being considered sub-attributes of a single LRM attribute. The generalization of many FRBR manifestation attributes to the single LRM attribute LRM-E4-A4 *manifestation statement,* was particularly significant in this context. Most of the properties in areas 1 (Title and statement of

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[5]   See http://iflastandards.info/ns/fr/
[6]   Riva, Pat. "Functional Requirements namespaces published." SCATNews #37 (June 2012), p. 13-14. https://www.ifla.org/files/assets/cataloguing/scatn/scat-news-37.pdf
[7]   https://www.ifla.org/node/1795
[8]   https://www.ifla.org/files/assets/cataloguing/isbd/isbd-frbr-mapping.pdf

responsibility) to 4 (Publication, production, distribution, etc.) of the ISBD map to the single LRM attribute LRM-E4-A4 *manifestation statement*, although in many cases these same properties are multiply mapped to several FRBR attributes. Presenting the alignment without the intervening FRBR alignment columns is much clearer and more concise.

The Task Group met in Paris on April 6-8, 2017 and finalized the document shortly thereafter. It is being presented for approval at WLIC 2017, making it the first completed alignment to IFLA LRM.

6.   **Reviewing FRBRoo for Conformance with IFLA LRM**

FRBRoo, now version 2.4, includes all three FR models and therefore a certain harmonisation had already been performed. Nonetheless, a detailed review is being conducted to fully bring the object-oriented model into conformance with the entity-relationship formulation of LRM. The first run-through was conducted at the FRBR/CRM Harmonisation meeting in Heraklion, Crete, on April 6, 2017 after a presentation of IFLA LRM. No major outstanding issues were discovered, but on the other hand IFLA LRM, being very abstract and high-level, could lead to the formulation of FRBRoo core, the simplified essential model, which would be easier to implement. Some areas of simplification have already been identified: conflating F3 Manifestation Product Type and F24 Publication Expression, dropping F14 Individual Work, defining F4 Manifestation Singleton as a set of one. Several additional meetings are already scheduled for 2017-2018. We expect to have the FRBRoo version 3 (probably renamed LRMoo ver. 1) ready by the end of 2018.

7.   **Conclusion**

While clearly following from the FR family of conceptual models, the IFLA Library Reference Model was prepared so as to make it more than just a textual report. The model definition is presented to be linked data ready. At the same time as the model definition document is completing the stages in the formal IFLA standards approval process, essential actions are already taking place to make LRM available as part of the infrastructure of the semantic web. Using the completed ISBD-LRM alignment, a formal RDF map from the ISBD namespace to LRM could be implemented as soon as the LRM namespace is declared. Development is now focused on bringing FRBRoo into conformance with LRM, so as to make LRMoo (or FRBRoo version 3) available as quickly as possible.

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