The Relationship between BIBFRAME and OCLC's Linked-Data Model of Bibliographic Description: A Working Paper

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Updates:
September 2013 — This version corrects a problem with attribution noted by reviewers of the previous draft. The models based on Schema.org described in Section 2 were derived from ideas being discussed by the W3C Schema Bib Extend community group but were developed by OCLC. The previous version of this draft incorrectly attributes this work to the W3C group. The analysis is otherwise unchanged.

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The ideas described in the document represent a team effort with my OCLC colleagues Jonathan Fausey, Ted Fons, Tod Matola, Richard Wallis, and Jeff Young. I am also grateful for comments by Karen Coyle and other members of the W3C 'Schema Bib Extend' Community Group on an earlier version of this draft, which led to many improvements. But I am responsible for remaining inaccuracies.

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Executive Summary

This document describes a proposed alignment between BIBFRAME and a model being explored by OCLC with extensions proposed by the Schema Bib Extend project, a W3C-sponsored community group tasked with enhancing Schema.org to the description of library resources. The key result is that the two efforts are complementary except for some common vocabulary required for the most important entities and relationships. The analysis presented here was prompted by the call at the end of the December 2012 BIBFRAME Early Experimenters Meeting for a set of Point or Position papers that work out technical issues and make recommendations for a number of sketchy, difficult, or controversial aspects of the BIBFRAME model. The description is based on a small dataset presented in the entirety in the Appendix. But the analysis is based on a larger dataset derived from the application of a mapping algorithm from MARC to BIBFRAME on all of WorldCat.org. This draft is being released as an OCLC report, but it is intended to be read as a working paper for the BIBFRAME community. Feedback is welcome and will be considered for incorporation into a more formal presentation of this material.

1. Schema.org and BIBFRAME

In the past year, OCLC researchers have tried to make the case that Schema.org is a suitable foundation for the description of library resources. The most important argument is that the library community cannot afford to ignore Schema.org because it has been defined by Google, Yahoo!, Bing and Yandex to be the standard of choice for the publication of structured data and intelligent consumption of web resources that the major search engines commit to recognizing. Though Schema.org was not designed as a replacement for library standards, OCLC's linked data experts and many other library technology experts have concluded that the ontology defines a reasonably coherent commonsense model with classes and properties that are important for simple descriptions of bibliographic resources managed by libraries—including *creative work*, *person*, *author*, *director*, *place*, *organization*, *publisher*, *copyright date*, *book*, *ISBN*, and so on. These concepts can be serialized in a variety of forms and are compatible with the modeling philosophy promoted by the Semantic Web community.

But anyone who has examined Schema.org could easily enumerate where it falls short in describing the domain of library resources and services. There is no representation of the FRBR Group I concepts Work, Expression, Manifestation and Item. There is no clear distinction between *content* and *carrier*. Very few relationships among creative works have been defined. There is no concept of *collection* or *series*. And there are no models of transactions involving library resources and the organizations that provide or receive them, such as libraries, universities, publishers, e-content aggregators, and data service providers. Schema.org might suffice for a description that is equivalent in detail to a Dublin Core record, and is perhaps incrementally better, but the designers never intended it to be a global ontology. Rather, Schema.org is proposed as a starting point, or a scaffolding to which a more detailed ontology designed by interested communities of practice would be attached.

OCLC's first-generation model of linked data for bibliographic descriptions attempted to address some of the shortcomings of Schema.org from the perspective of librarianship by proposing a 'library' extension vocabulary, which established a distinction between content and carrier and added terms such as 'OCLCnumber' and 'holding' to the description. The full ontology is available at the website entitled Experimental "library" extension for use with Schema.org and the markup has been applied to records in WorldCat.org. For example,

Figure 1.1 shows screenshots from WorldCat.org of a MARC record that describes the hardback edition of Frank Herbert's novel *Dune* published in 1965. At the very bottom of the page is a tab titled *Linked Data,* where a human-readable view of the corresponding Schema.org microdata published in June 2012 can be viewed. This markup is now being regenerated to reflect the improvements to the Schema.org-plus-extensions model discussed in this report.

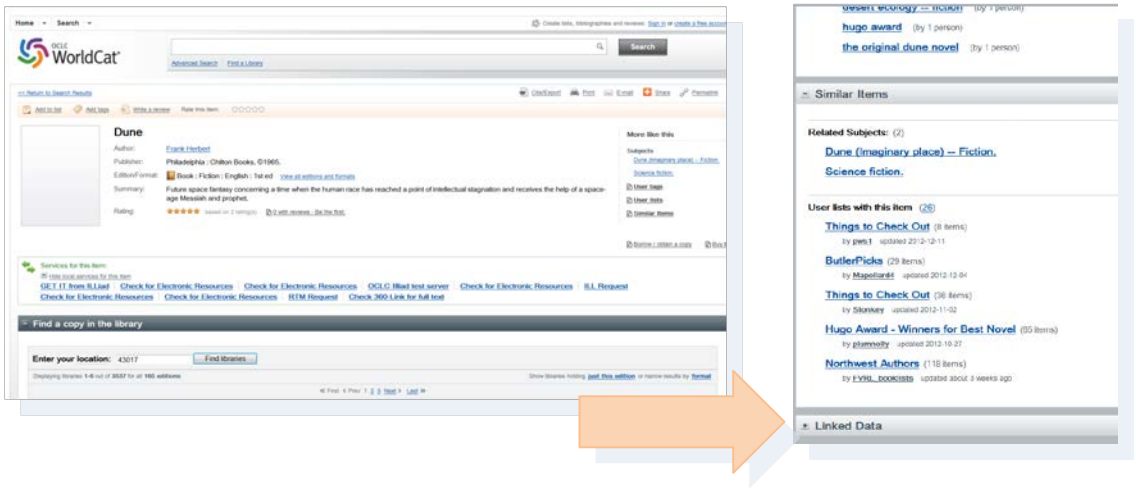

Figure1.1. Locating the Linked Data markup in WorldCat.org

Since the BIBFRAME draft standard was released to the Early Experimenters several months after the OCLC model was published, OCLC researchers have confronted the reality that the two standards must be aligned because they describe the same resources. Yet many issues have been raised about what the alignment should look like. Do the two models complement or compete with one another? Formally, BIBFRAME recognizes a simplified view of the FRBR hierarchy, but it is not clear how to associate the BIBFRAME Work and Instance classes with the much more broadly defined Schema.org CreativeWork class. OCLC's proposed 'library' vocabulary is largely redundant with some of the BIBFRAME Work and Instance subclasses. The instance data produced by the BIBFRAME community reveals different approaches to the modeling of people, places, things and the authorities that describe them. Yet so many concepts are equivalent that OCLC can produce BIBFRAME markup from WorldCat records that is as rich as the corresponding Schema.org markup.

Now that my OCLC colleagues and I have had a few months to think about the problem, we believe that the relationship between the two models is much clearer. Though many of the low-level details still resemble the markup visible in WorldCat.org, recent work at OCLC has taken advantage of improvements to Schema.org, in particular the incorporation of the GoodRelations ontology. The OCLC model has also been informed by our participation in the W3C Schema Bib Extend Community group, which aims make formal proposals to Schema.org

for vocabulary that will ease the task of library resource description. This group is facilitated by Richard Wallis, an OCLC colleague and a recognized thought leader in Semantic Web and Linked Data technology. The new OCLC model makes use of two properties being discussed in the Schema Bib Extend community, hasInstance and isInstanceOf, whose semantics are similar to the properties with the same names defined in BIBFRAME. In addition, we now believe that GoodRelations offers a way to represent some of the concepts in the FRBR Group I hierarchy without having to propose an extensive new vocabulary. Finally, the 'library' vocabulary extensions for format and content types defined in the initial draft of the OCLC linked data release will soon be deprecated.

The cumulative effect of these three activities--defining a small number of properties whose role in model-building is essentially 'meta-,' addressing the need to represent FRBR Group I concepts, and eliminating redundant vocabulary—is that the OCLC and BIBFRAME models are now syntactically more compatible but semantically more complementary. This is a step forward. As we see it, the two models have different, but overlapping target audiences. BIBFRAME is designed for practitioners in the library community who create and manage descriptions that facilitate access to library resources. And Schema.org, with enhancements being discussed by the Schema Bib Extend community, provides a simplified description of library resources that can be integrated with related objects on the wider web and discovered by general-purpose search engines. As Richard Wallis said in a recent interview with Semanticweb.com:

> 'You will never use [S]schema [.org] as a vocabulary to run a library off of it. It won't get deep and rich enough for all the subtleties in MARC data.' But what it will do is help on the search engine front, so that bibliographic data can be marked up in a way that search applications can understand and so use appropriately – and that's what the average user probably will appreciate more. [Source: The Future of Libraries, Linked data and Schema.org Extensions.]

Going forward, we envision a model for describing library resources in which key concepts required for discovery are expressed in Schema.org, while the details required for curation and management are expressed in BIBFRAME and associated standards defined in the library community. Though the exact shape of this outcome is still being developed, this article can be read as a progress report on the goal of aligning BIBFRAME and a slightly enhanced Schema.org that describes preliminary results, identifies technical roadblocks and divergent perspectives, and proposes a work agenda for future coordinated effort.

The contents of this report reflect outcomes of OCLC's involvement in three work streams. First, OCLC continues to conduct experiments with linked data on its publicly accessible data stores with the aim of creating post-MARC models of the entities and relationships required for the description of creative works of interest to libraries. Second, OCLC's participation in

the BIBFRAME Early Experimenters' group prompted us to analyze the relationship of our models to BIBFRAME and summarize our findings in a position paper, which was the precursor to this document. Finally, OCLC's participation in the W3C Schema Bib Extend community group required us to re-examine some of our initial assumptions about how to incorporate Schema.org into models of library resources. We now realize that the library community needs to be conservative in proposing formal changes to Schema.org. Yet we also believe that the existing ontology, especially with the introduction of GoodRelations, is deep enough to create rich and subtle descriptions of many library resources and the events that impact them.

The models described in this document were developed at OCLC and reflect this new understanding. They adhere to the minimalist philosophy emerging from the Schema Bib Extend initiative, which recommends starting with a description using Schema.org and defining new vocabulary only if gaps and inconsistencies impede progress. But because of this emphasis on vocabulary definition, the Schema Bib Extend community group has been less focused on the task of constructing models, which is essential for OCLC to achieve goals in its own work agenda. Thus the models described here go beyond what has been formally endorsed by the W3C group. But wherever possible, the models reflect OCLC's experiments with ideas that have taken shape in the Schema Bib Extend community group discussion. Because of its grounding in Schema.org, we have dubbed the results 'The OCLC Schema Model,' or the 'OCLC Model,' for short.

OCLC's involvement in the BIBFRAME Early Experimenters' group also created a need to show how these models can incorporate published vocabulary defined by standards experts in the library community and elsewhere. As in the BIBFRAME initiative, OCLC's models are being developed with an Agile approach, which features a rapid translation of draft models into at-scale experimental prototypes. Using this approach, we have created two versions of Schema.org-compliant markup on WorldCat.org and have reused much of the process stack to produce corresponding BIBFRAME markup. This is the data upon which the analysis presented in this article is based, but it is undergoing continuous revision.

This article is organized as follows. Section 2 describes the current draft of OCLC's models using a set of descriptions of various forms of Frank Herbert's *Dune*. Section 3 shows how the same descriptions would be marked up in BIBFRAME, revealing similarities and differences between the two models. Section 4 concludes with remarks about how to carry this work forward in a coordinated fashion.

2. Resource Descriptions in the OCLC Schema Model

This section describes highlights from the model based on Schema.org that is now visible from the linked-data markup on WorldCat.org.

2.1. The representation of FRBR Group I entities

The main objective of the redesign is to improve the representation of the FRBR hierarchy using concepts already defined in Schema.org. Since the application of the FRBR hierarchy requires the association of descriptions with differing degrees of abstraction, the Schema Bib Extend community is also considering two properties, tentatively named hasInstance and isInstanceOf, whose semantics resemble the BIBFRAME properties with the same names. A consequence of these improvements is that the new model of bibliographic data is much more closely aligned than its predecessor with the high-level design of BIBFRAME. One outcome is that BIBFRAME markup can be produced simply by relabeling, and little else, at least for simple resource descriptions.

Given the constraints of working with an ontology designed by general-purpose search engines for a broad array of needs, the Schema Bib Extend vocabulary development and OCLC's corresponding modeling effort starts with an obvious question. How can Schema.org be used most productively to describe library resources? The resulting description may be incomplete or may eventually need to be supplemented, but how far does it take us? We thus adopt the strategy promoted by the Schema Bib Extend community to start with existing Schema.org concepts and graft a librarian's understanding to them, proposing extensions only where absolutely necessary.

Since the goal is some representation of the FRBR hierarchy in Schema.org, the challenge is especially difficult. To the library community, the distinctions in the FRBR hierarchy are important and even fundamental to the description of library resources and the transactions that involve them. Yet FRBR is not represented in Schema.org. As Dan Brickley said in the inaugural meeting of the Schema Bib Extend community group, FRBR concepts were omitted from Schema.org because nobody understands them except librarians. To make matters more confusing, Schema.org, as well as models developed in the library community, both have some concept of 'Work' but the definitions are probably different. In Schema.org, the 'Work' is the concrete thing that web users are looking when they search Google for books, DVDs and so on. But to modeling experts in the library community, a Work is much more abstract—it is a unique intellectual endeavor with an ascribed authorship, which is imperfectly represented in library systems as a cluster of descriptions, or a set of properties that are common among the editions, formats, or translations.

2.1.1. An example

Figure 2.1 is a schematic representation of a small dataset in the latest draft of OCLC's model. In these examples, Frank Herbert's *Dune* is described as two separate but related FRBR Works realized as a hardcover book and a DVD movie. Each description is labeled as a numbered 'bundle' of related statements. The syntax shown in Figure 2.1 is pseudo-code for an RDF/Turtle representation, which is fully reproduced in Example 1 in the Appendix, accompanied by the RDF/XML that was automatically generated from the Turtle source by a web-accessible RDF translator. The bundles correspond to rdf:description statements in RDF/XML.

Following the Turtle convention, statements beginning with 'a' (such as 'a schema:Movie' in Bundle 1) represent shorthand for the rdf:type statement in RDF/XML. Thus each of the bundles describes a resource representing a particular type of schema:CreativeWork: Bundle 1 describes a movie; Bundle 2 is describes a book; and Bundle 5 describes a hardcover book with the ISBN 0801950775. Literal strings are enclosed in quotes and resolvable URIs are enclosed in brackets. For example, <herbert:1> in Bundle 1 is a human-readable representation of the URI http://herbert.example/1, a pointer to the rdf:about statement in RDF/XML. And <Frank Herbert> is shorthand for http://viaf.org/viaf/5908379, a pointer to the entry in VIAF.org that identifies the science fiction author Frank Herbert.

In sum, the data described in these examples and throughout this report are presented in three levels of abstraction: a simplified graphic that makes it easy to visualize important entities and relationships; the analogous Turtle code; and the corresponding RDF/XML code that could be used to represent instance data in a working system.

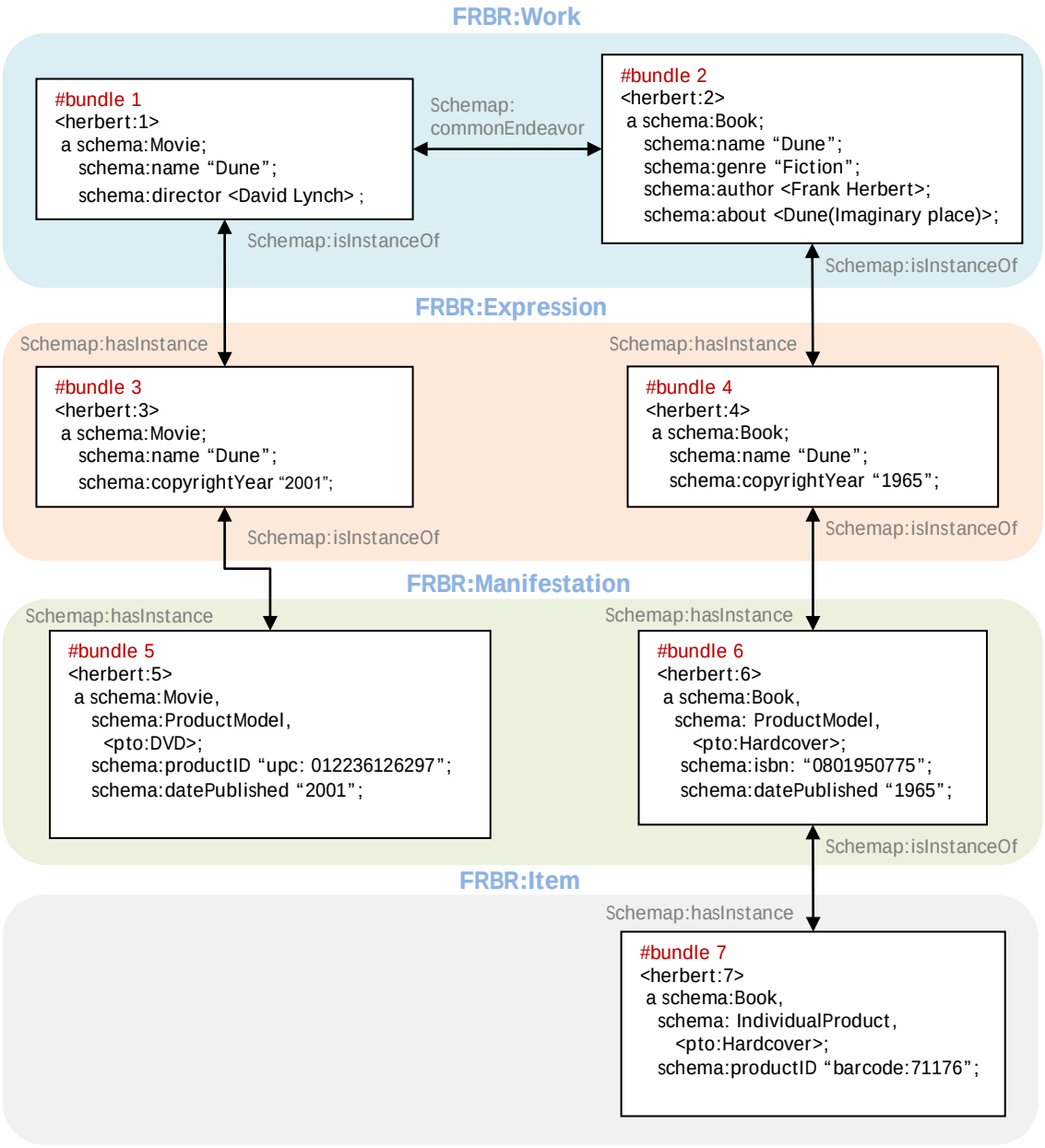

Figure 2.1. A schematic representation of an 'OCLC Schema' dataset

At first glance, the levels of the FRBR hierarchy appear to be differentiated primarily by degree of specificity. Thus a Work has an author, title, subject, and content type; an Expression appends this description with a copyright date; the Manifestation description adds properties for publication dates and product identifiers; and the Item description adds a barcode.

The draft Schema Bib Extend properties schemap:hasInstance and schemap:isInstanceOf associate descriptions in the same hierarchy and are analogous to the already-defined schema:Model. Another draft property, schemap:commonEndeavor, defines a relationship between entities in different hierarchies whose content is derived from the same creative act. In this example, commonEndeavor can be interpreted as a cover term for an RDA relationship designator such as *Motion Picture Adaptation Of*, which might be more descriptive in this context. Unfortunately, many RDF implementations of RDA relationships require a domain and range explicitly defined as FRBR entities, so they are formally incompatible with descriptions of schema:CreativeWork unless some technical adjustments are made. Alternatively, the Open Metadata Registry implementation invites the inference that RDA relationships such as motionPictureAdaptationOf apply only to descriptions typed as FRBR Works, though this correspondence is not strictly required.

This example illustrates two extensions being discussed in the Schema Bib Extend community. The full list of candidate extensions to Schema.org is described in the Schema Bib Extend wiki. The larger point is that, in proposing descriptors for library resources that fill gaps in Schema.org, the Schema Bib Extend initiative focuses on generic recommendations such as commonEndeavor and hasInstance, which may be useful to other communities of practice. This shift in focus implies a decision by the Schema Bib Extend community to defer to the major library standards initiatives, including BIBFRAME, to develop vocabulary required for detailed descriptions of library resources.

2.1.2. A detailed look at the FRBR hierarchy in the OCLC Schema model

Despite some shortcomings, the OCLC model offers several improvements over the linked data model that was published on WorldCat.org about a year ago. Most important is a set of conventions for expressing FRBR relationships and a refactoring of the Content/Carrier distinction without the need to define an extensive 'library' vocabulary, as was necessary in the previous model. But the search continues for a satisfactory solution to the problem of explicitly defining FRBR concepts in a description grounded in Schema.org, an issue that will be discussed in detail below.

FRBR Works and Expressions. As Bundles 1-4 in Figure 2.1 imply, best-practices conventions might be used to select the Schema:CreativeWork properties associated with Works and Expressions. In this scheme, it would be possible to say that when only titles, subjects, and creators are mentioned, the description for a Schema:CreativeWork refers to a FRBR Work; and when copyright dates and genres are present, the description is equivalent to a FRBR Expression. But since best-practices conventions are almost certainly not strong enough to identify such important concepts, OCLC and members of the Schema Bib Extend community

are examining alternatives. Perhaps it is realistic to acknowledge that the distinction is simply not relevant to the Schema.org view of library resource descriptions and that a description tagged with Schema:CreativeWork will always be ambiguous between a FRBR Work and the FRBR classes containing more detail. But one thing is clear: if the distinction must be retained, it will have to be expressed in another namespace defined and maintained by the library community.

FRBR Manifestations. Though much more work needs to be done to represent FRBR Works and Expressions in the OCLC Schema model, the treatment of Manifestations represents a true advance over the previous model published on WorldCat.org. OCLC researchers are exploring the possibility that Manifestations can be modeled by making reference to Schema:Product and The ProductTypes Ontology. Here is the IFLA definition:

> [A] *Manifestation* is "the physical embodiment of an expression of a work. As an entity, manifestation represents all the physical objects that bear the same characteristics, in respect to both intellectual content and physical form." Source: *Functional Requirements for Bibliographic Records* < http://archive.ifla.org/VII/s13/frbr/frbr1.htm>

This definition specifies three modeling requirements:

1. The model must link to a description of the Work;
2. The model must describe the physical embodiment of the Work; and
3. Where relevant, the model must refer to a class of like objects.

To illustrate, the essential statements in Bundles 4 and 6 are reproduced in Figure 2.2 below as RDF/XML. The first block, representing Bundle 4, describes the 'Book' Expression, while the second block of RDF/XML statements describes Bundle 6, the 'Hardcover' Manifestation.

The linking function is achieved by the schemap:hasInstance and schemap:isInstanceOf properties. The Manifestation description is linked to the Expresssion description, which in turn is linked to the Work description of *Dune*.

```
<rdf:Description rdf:about="http://herbert.example/4">
  <schema:copyrightYear>1965</schema:copyrightYear>
  <schemap:isInstanceOf rdf:resource="http://herbert.example/2"/>
  <schemap:hasInstance rdf:resource="http://herbert.example/6"/>
  <rdf:type rdf:resource="http://schema.org/Book"/>
  <schema:name>Dune</schema:name>
</rdf:Description>
```

```
<rdf:Description rdf:about="http://herbert.example/6">
  <schema:isbn>0801950775</schema:isbn>
  <schemap:isInstanceOf rdf:resource="http://herbert.example/4"/>
  <rdf:type rdf:resource="http://www.productontology.org/id/Hardcover"/>
  <rdf:type rdf:resource="http://schema.org/ProductModel"/>
  <rdf:type rdf:resource="http://schema.org/Book"/>
  <schema:datePublished>1965</schema:datePublished>
</rdf:Description>
```

Figure 2.2. <rdf:Description> blocks illustrating CreativeWork, ProductModel, and Product Type Ontology resource types

The Manifestation description in Figure 2.2 also describes the physical embodiment of the work. This simplified example includes a publication date, the ISBN, and the Carrier type 'Hardcover.'

Finally, the Manifestation description statements in Figure 2.2 makes a reference to a class of like objects through the rdf:type statements. The first two rdf:type statements assert that the resource being described is simultaneously a schema:Book and a schema:ProductModel, a subclass of schema:Product. The schema:Product class makes many properties available to the description, including physical characteristics and availability, while the ProductModel subclass makes it possible to state that the resource is member of a class of objects with the same physical form. The third rdf:type statement asserts that the resource is a member of the class of 'hardcover' products described in the Product Types Ontology. Of course, some of the PTO classes as well as some of the properties defined for schema:Product are also defined in schema:CreativeWork. But this overlap is a direct consequence of the fact that the GoodRelations ontology for e-commerce has only recently been merged with Schema.org. But these redundancies are most likely a temporary nuisance that will be addressed in a future version.

The rdf:type statements perform two valuable functions in the OCLC model. First, the reference to the Product class in the Schema.org ontology allows us to describe two loosely

coupled facets about a library resource. As a schema:CreativeWork, the resource is a work of creative endeavor, which has a title and a subject but does not necessarily have a particular physical realization. And as a schema:Product, the book can be described as a tangible object in the marketplace, which can be bought, sold, traded, lent, and managed.

Second, the reference in the rdf:type statement to the Product Types Ontology eliminates, at least in principle, the need to develop and maintain a list of content types and physical carriers. Instead, this taxonomy is being proposed by the user community and published as human-readable pages in Wikipedia and as corresponding machine-processable concepts in DBpedia. Many of the content and carrier types of interest to the library community are already represented, such as film, book, hardcover, DVD, Compact Disc, and so on. The culture of cooperation between Wikipedia and the library community could be enlisted to address the gaps and descriptive inadequacies. As participants in the BIBFRAME Early Experimenters group, we recommend that BIBFRAME develop its own policy with regard to the Product Types Ontology. Nevertheless, we see little need to define and maintain a competing vocabulary for content types and carriers.

FRBR Items. OCLC is exploring the possibility that schema:IndividualProduct, a sibling of schema:SomeProducts, corresponds reasonably well to the definition of FRBR Item. In the marketplace, an IndividualProduct is 'my' lawnmower produced by a particular manufacturer with a particular model number, which I may want to trade or sell because it is not as nice as the latest model. Analogously, a copy of *Dune* held by Grandview Heights Public Library may also be interpreted as an IndividualProduct, which is autographed by the author, is missing Page 15, and has a unique spine label or barcode.

2.1. 3. FRBR and the OCLC Schema model: the big picture

To summarize, three of the FRBR Group I concepts can be represented in the OCLC model by referring to the schema:Product class as well as the schema:CreativeWork class.

- schema:CreativeWork with no co-occurring schema:Product may be interpreted as a FRBR Work. As noted in the discussion above, however, such a description is probably best interpreted as ambiguous. We continue to work on a solution to represent the library community's concept of 'Work' more formally in a description that is compatible with Schema.org.

- schema:CreativeWork + schema:ProductModel can be interpreted as a FRBR Manifestation.
- schema:CreativeWork + schema:IndividualProduct can be interpreted as a FRBR Item.

To help visualize these relationships, the subclasses of Schema:Product are shown in Figure 2.3.

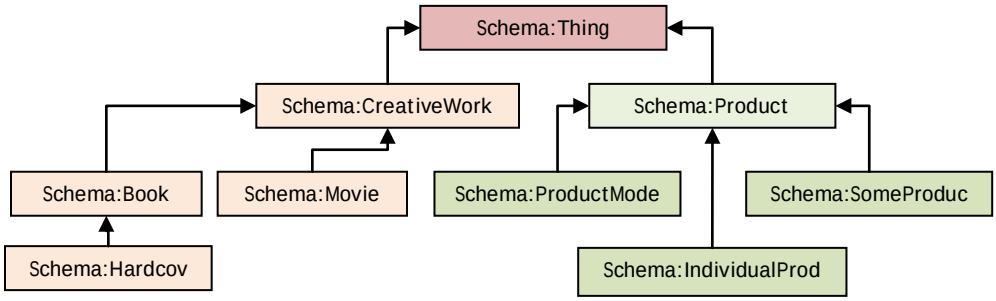

Figure 2.3. Schema.org CreativeWork and Product ontologies

Of course, OCLC's model can also be interpreted as an argument that a representation of FRBR in a description consistent with Schema.org requires a formal representation in a published vocabulary that is maintained separately from Schema.org and harmonized with it. To move forward, two issues must be resolved. First standards experts must reach agreement on working definitions of key concepts. Then we must solve the technical problem of mismatched expectations about domain and range values for the description of relationships that are important for library resources.

The technical issue is the easier of the two to resolve. As noted in the introductory discussion in this section, one obstacle to the adoption of FRBR (and RDA) concepts in the OCLC Schema model is the expectation that RDA properties such as motionPictureAdaptationOf describe explicitly defined FRBR Works or Expressions and are therefore not compatible with the CreativeWorks defined in Schema.org. But the above discussion of FRBR Manifestations and Items points to a possible solution. Since Schema.org permits multiple type assignments, nothing prevents the assignment of an additional rdf:type from the FRBR namespace.

For example, the type frbr:Expression could be assigned to Bundle 4, as shown in Figure 2.4, building on the RDF/XML statements listed in Figure 2.2; likewise, frbr:Manifestaton and frbr:Item could be assigned, perhaps with much more confidence, to Bundles 5-7. And once the descriptions have been given FRBR type assignments, they could be related by RDA relationship properties that are much more specific than schemap:commonEndeavor.

```
<rdf:Description rdf:about="http://herbert.example/4">
  <schema:copyrightYear>1965</schema:copyrightYear>
  <schemap:isInstanceOf rdf:resource="http://herbert.example/2"/>
  <schemap:hasInstance rdf:resource="http://herbert.example/6"/>
  <rdf:type rdf:resource="http://vocab.org/frbr/core/Expression"/>
  <rdf:type rdf:resource="http://schema.org/Book"/>
  <schema:name>Dune</schema:name>
</rdf:Description>
```

Figure 2.4. A hypothetical <rdf:Description> block illustrating a frbr:Expression type assignment

Unfortunately, library standards experts have not reached consensus about how to define FRBR Works or how to draw the line between Works and Expressions. In one view, a Work is extremely abstract and refers only to a recognizably unique piece of intellectual content with no assumptions about how it is physically realized. In fact, the Schema Bib Extend community has discussed a model that collects Book and Movie Expressions into a single 'Superwork.' But another view emerging from large-scale computing environments is that the definition of Work is operationalized as a set of Manifestations that have common properties such as authors, titles, and subjects. Perhaps the definition of Work will not be standardized anytime soon because it must meet the needs of perceived relevance to particular resource types or use cases and ease of computation, which may evolve over time. Nevertheless, these definitions would eventually need to be associated with a common published definition if the goal is to promote a common Work concept. Of course, this is a contentious topic and, as of this writing, too much is unresolved to propose a realistic formal model.

Another, perhaps less critical, conceptual problem is that Schema Product, which figures prominently in the OCLC model, is an imperfect fit for descriptions of library resources. It is possible to argue that the Product class does not encompass the entire set of objects that a library must manage because theses, dissertations, archival materials, and virtual collections are not typically found among the objects that are bought and sold in the marketplace. To keep the semantics clear, a library standards expert would need to define a class related to Schema:Product, perhaps with input from the Schema Bib Extend community.

2.1.4. A note about Holdings

Before leaving the topic of FRBR in the OCLC Schema model, I want to mention the relevance of more specific subclasses of schema:Product in the description of library holdings. A simple example is part of the dataset listed in Example 1 in the Appendix, which corresponds to Bundle 7 in Figure 2.1. The RDF/XML statements are reproduced in Figure 2.5. Here the

rdf:type is schema:IndividualProduct, which is modified by schema:inventoryLevel to assert the availability of a single hardcover copy of *Dune* that is in damaged condition. This description features a barcode instead of an ISBN, though this property can be recovered by following the isInstanceOf link to Bundle 6, the Manifestation description.

```
<rdf:Description rdf:about="http://herbert.example/7">
    <schema:productID>barcode:71176</schema:productID>
    <schemap:isInstanceOf rdf:resource="http://herbert.example/6"/>
    <schema:itemCondition
rdf:resource="http://schema.org/DamagedCondition"/>
    <rdf:type rdf:resource="http://schema.org/IndividualProduct"/>
    <rdf:type rdf:resource="http://www.productontology.org/id/Hardcover"/>
    <rdf:type rdf:resource="http://schema.org/Book"/>
    <schema:inventoryLevel rdf:nodeID="ub19bL72C23"/>
  </rdf:Description>

  <rdf:Description rdf:nodeID="ub19bL72C23">
    <rdf:type rdf:resource="http://schema.org/QuantitativeValue"/>
    <schema:hasValue>1</schema:hasValue>
  </rdf:Description>
```

Figure 2.5. An RDF/XML description of a library resource with holdings

2.2. People, Places, Concepts, and Authorities

So far, this section has been devoted to a description of the FRBR hierarchy in OCLC's models of bibliographic description. Nevertheless, much of the design remains the same as the published version available from WorldCat.org—in particular, the references to authoritative resources such as library authority files and authority-file aggregations such as VIAF in the description of persons, organizations, places, and topics.

To illustrate, a slightly more detailed representation of Bundle 1 is depicted in Figure 2.6, here expressed as RDF/XML. It contains three rdf:Description blocks. The first is the proxy FRBR Work description, first mentioned in Figure 2.1, containing the rdf:type assignment of schema:CreativeWork and the properties schema:name, schema:director, and schema:about. The second block describes the 'person' resource referenced by the schema:director statement, namely *Herbert, Frank*. And the third block describes a 'concept' resource referenced by the schema:about statement, namely *Dune (Imaginary place)*.

```
  <rdf:Description rdf:about="http://herbert.example/1">
    <rdf:type rdf:resource="http://schema.org/Movie"/>
    <schema:about rdf:resource="http://id.worldcat.org/fast/899474"/>
    <schema:name>Dune</schema:name>
    <schemap:CommonEndeavor rdf:resource="http://herbert.example/2"/>
    <schema:director rdf:resource="http://viaf.org/viaf/164455045"/>
    <schemap:hasInstance rdf:resource="http://herbert.example/3"/>
  </rdf:Description>

  <rdf:Description rdf:about="http://viaf.org/viaf/5908379">
    <rdf:type rdf:resource="http://schema.org/Person"/>
    <schema:name>Herbert, Frank</schema:name>
    <madsrdf:isIdentifiedbyAuthority
rdf:resource="http://id.loc.gov/authorities/names/n80044450"/>
  </rdf:Description>

  <rdf:Description rdf:about="http://id.worldcat.org/fast/899474">
    <rdf:type rdf:resource="http://bibframe.org/vocab/TopicalConcept"/>
    <schema:name>Dune (Imaginary place)</schema:name>
    <schemap:sameThingAs
rdf:resource="http://id.loc.gov/authorities/subjects/sh92003142"/>
  </rdf:Description>
```

Figure 2.6. RDF/XML fragments describing a person and a topic

As in the earlier version of OCLC's model, the rdf:about statement in the description of people, places, organizations, and topics refers to the real-world object, whose closest information-object proxy is an authority-file aggregation. This is the reasoning behind the reference to VIAF in the description of Frank Herbert in the second rdf:Description block. But in the description of concepts, such an aggregation is not yet available and the rdf:about statement refers instead to a locally trusted authority, such as FAST, as shown in the third rdf:Description block. The description can be enhanced with equivalence statements asserting that the same real-world object has a controlled name in another authority. The third block shows the use of the draft Schema Bib Extend property schemap:sameThingAs, which is used to connect the FAST and LCSH descriptions of *Dune*, the imaginary place. But mads:isIdentifiedByAuthority can also be used in this context.

Anticipating the discussion in the next section, the description also contains an rdf:type statement referring to the proposed BIBFRAME property topicalConcept. Since Schema.org does not have this level of detail, the BIBFRAME descriptor has been incorporated and tagged with an appropriate namespace. This example is somewhat contrived. But once the BIBFRAME standard has been fleshed out, we expect to incorporate many more BIBFRAME statements into descriptions that are anchored in Schema.org. Of course, it is possible to argue that *Dune (Imaginary place)* is a geographic, not a topical term. But because the MARC source of

this data is 650 $a, it is interpreted as a topical term by a reasonably straightforward crosswalk, and a special process would be required to label it otherwise.

3. A Corresponding BIBFRAME Representation

This section walks through a BIBFRAME description that corresponds closely to the descriptions of *Dune* based on Schema.org discussed above. The essential components are summarized in Figure 3.1 using the same conventions as before. Since the BIBFRAME model is undergoing revision as this document is being written, the remarks in this section are based on the version that was made available to the BIBFRAME Early Experimenters in late 2012. Occurrences of the bfp: namespace in the examples identify a BIBFRAME entity proposed either by the BIBFRAME modeling experts and not yet adopted, or by OCLC colleagues tasked with generating BIBFRAME datasets from WorldCat.org.

A glance at Figure 3.1 reveals the most obvious difference between the two descriptions: the core BIBFRAME model has two levels instead of four, a consequence of the fact that the BIBFRAME Group I entity Work encompasses FRBR Work and Expression, while BIBFRAME Instance encompasses FRBR Manifestation and Item. The other two BIBFRAME Group I entities discussed in the BIBFRAME Model Primer, Annotation and Authority, are not required for the dataset described in this article.

As a result, the BIBFRAME dataset has fewer bundles with more detail. Given the uncertainty of where to draw the Work/Expression line in the OCLC Schema model, the corresponding BIBFRAME Work bundles are descriptively equivalent. But the BIBFRAME Instance descriptions lose distinctions that can be formally expressed in OCLC's model. For example, Bundle 4 is a BIBFRAME Item with an ISBN and a barcode, indicating that it is a description to which holdings data could be attached. As described in Section 2.1.3, the OCLC model splits this bundle into two descriptions, one with an rdf:type assignment of schema:ProductModel and the other with schema:IndividualProduct. Yet in other respects, the two models have a similar configuration. Thus the BIBFRAME property isBasedOn, like the draft Schema Bib Extend property commonEndeavor, accomplishes the goal of associating the movie and book versions of *Dune*. And the BIBFRAME properties hasInstance and isInstanceOf do the job of linking more and less abstract versions of a resource description, as do the draft Schema Bib Extend properties with the same name.

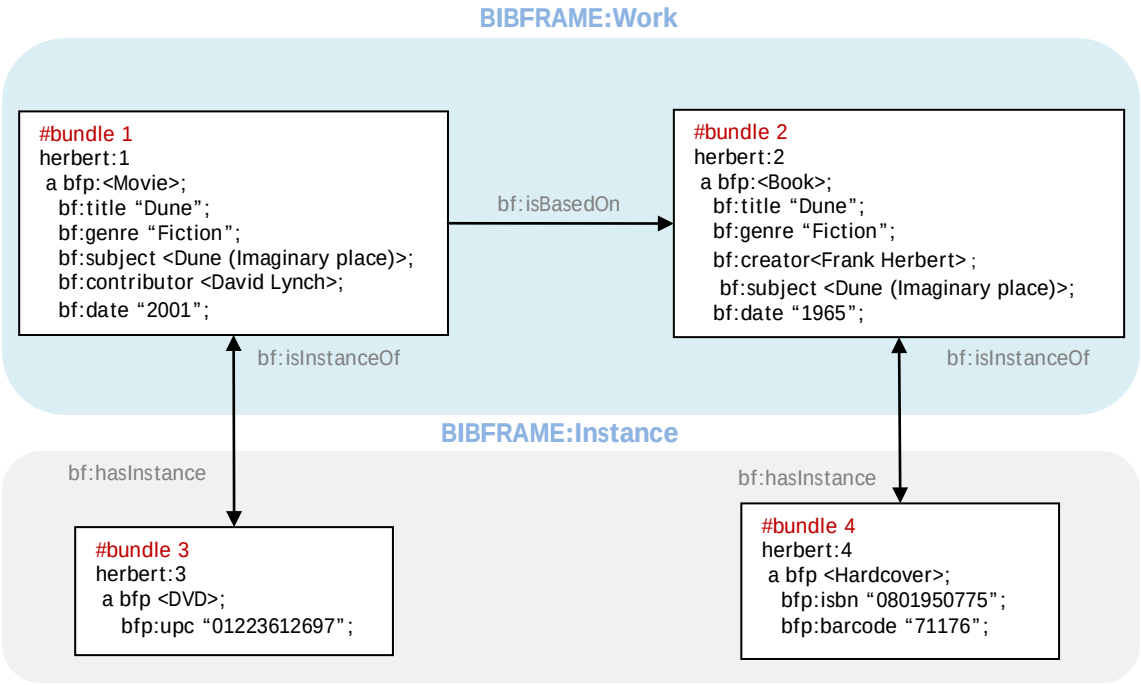

Figure 3.1. A schematic representation of BIBFRAME descriptions for Frank Herbert's 'Dune'

Figures 2.1 and 3.1 are designed to show that BIBFRAME and the OCLC models have enough high-level similarities that, at least for simple resource descriptions, one description can be mechanically converted to the other without much loss of information. This alignment implies the existence of a set of properties that link different levels in the model and a set of classes and properties that have essentially identical definitions, including title, creator, person, publisher, organization, place, subject, genre, and date, as well as the names of content types and carriers. The result is slightly more descriptive than a Dublin Core description. During the next few months, members of the BIBFRAME community should participate in the Schema Bib Extend community discussion to answer some important questions. Is a Dublin-Core-like description good enough to support the discovery of library resources on the open web? Are there any catastrophic omissions that need to be lobbied for? And are the superficially similar Schema.org definitions good enough to be used in BIBFRAME without having to be redefined?

But it is unclear how to map the BIBFRAME Group I entities. On the one hand, the OCLC Schema model does yet not formally type FRBR Work and Expression, though it draws the line in the same place as BIBFRAME Work, as the examples depicted in Figure 2.1 and 3.1 suggest. Perhaps BIBFRAME Work could do the job, but only if there is no anticipated need to draw a

principled distinction between FRBR Work and Expression. But we are more confident in arguing that asserting that BIBFRAME Instance is too broad because of the many needs to distinguish between Manifestations and Items in a machine-processable description.

In addition, the two models exhibit the following differences:

- BIBFRAME has a richer and deeper vocabulary for describing library resources than the OCLC Schema model.

  An examination of The BIBFRAME Model Primer reveals that many properties in addition to isBasedOn are already present in the draft BIBFRAME standard. And the list will only grow as more entities and relationships are incorporated from RDA and other important library standards, including mappings from MARC. A model that is formally typed with Schema.org is not ever expected to achieve this level of detail.

  Nevertheless, OCLC and other members of the Schema Bib Extend community also need to produce rich descriptions that support the business of describing and delivering library resources. To re-engineer OCLC's WorldCat database as a fully functional semantic web resource, BIBFRAME and other important standards will be enlisted to create descriptions of bibliographic data that exceed the descriptive capacity of Schema.org.

- The models for the description of content types and carriers appear to be similar now, but they could diverge.

  In the BIBFRAME data dumps that OCLC has prepared, BIBFRAME encodings of content types look like the first rdf:Description block shown in Figure 3.2 below, which is the RDF/XML representation of the Hardcover edition of *Dune*. The second rdf:Description block is the corresponding OCLC Schema description, which is structurally identical. The only important difference is that the rdf:type is assigned from the Product Types Ontology instead of BIBFRAME. The third rdf:Description block describes a hypothetical graphic paperback novel edition of *Dune*. Here the creator of the description in OCLC's model has determined that the 'paperback' concept is represented adequately in the Product Types Ontology, but the 'graphic novel' concept is represented best in BIBFRAME, so the rdf:type statements refer to both ontologies.

```
<rdf:Description rdf:about="http://herbert.example/4">
    <bf:isbn>0801950775</bf:isbn>
    <bf:isInstanceOf rdf:resource="http://herbert.example/2"/>
    <bf:date>1965</bf:date>
    <bfp:barcode>1965</bf:barcode>
    <rdf:type rdf:resource="http://bibframe.proposed.org/Hardcover"/>
  </rdf:Description>
```

```
<rdf:Description rdf:about="http://herbert.example/6">
    <schema:isbn>0801950775</schema:isbn>
    <schemap:isInstanceOf rdf:resource="http://herbert.example/4"/>
    <rdf:type
rdf:resource="http://www.productontology.org/id/Hardcover"/>
    <rdf:type rdf:resource="http://schema.org/ProductModel"/>
    <rdf:type rdf:resource="http://schema.org/Book"/>
    <schema:datePublished>1965</schema:datePublished>
  </rdf:Description>
```

```
<rdf:Description rdf:about="http://herbert.example/hypothetical">
    <schema:isbn>142701016</schema:isbn>
    <schemap:isInstanceOf rdf:resource="http://herbert.example/4"/>
    <rdf:type
rdf:resource="http://www.productontology.org/id/Paperback"/>
    <rdf:type
rdf:resource="http://bibframe.proposed.org/GraphicNovel"/>
    <rdf:type rdf:resource="http://schema.org/ProductModel"/>
    <rdf:type rdf:resource="http://schema.org/Book"/>
    <schema:datePublished>2010</schema:datePublished>
  </rdf:Description>
```

Figure 3.2. A hypothetical mixed description of format types for Frank Herbert's 'Dune'

The freedom to mix and match implied in the above examples assumes that the BIBFRAME 'Content Type' and 'Carrier' vocabularies will eventually be represented in an authority file describing a set of concept classes, each of which can be referenced by a globally unique identifier. This is also how the Product Types Ontology is designed. And the same design governs the representation of concepts in the Library of Congress Subject Headings, FAST, and other linked-data representations of library authority files. If this design is adopted for the proposed BIBFRAME vocabularies, it can be interchanged with references to the Product Types Ontology. But if the BIBFRAME model for these concepts

turns out to be drastically different, users of the Product Types Ontology will have to write mapping rules and conversion software.

- BIBFRAME and the OCLC Schema model could end up with different treatments of Authorities and their real-world referents.

  As of this writing, the representation of subjects and other authorities in BIBFRAME is undergoing revision. As we demonstrated in the OCLC data dump produced in December, BIBFRAME Authorities can be coded isomorphically to the OCLC model using only the RDF meta-language, supplemented with a namespace-specific 'subject' label. Thus the OCLC model is parsimonious, requiring no reference to an Authority class, or to an open-ended collection of properties that name particular authority files, such as bf:hasVIAFlink. And it can be mapped to BIBFRAME simply by relabeling. For example, the reference to the subject heading *Dune (Imaginary place)* discussed in the context of the OCLC model in Section 2.2 is reproduced below in the first rdf:Description block; the analogous BIBFRAME statements appear below it.

```
    <rdf:Description rdf:about="http://id.worldcat.org/fast/899474">
      <rdf:type rdf:resource="http://bibframe.org/vocab/TopicalConcept"/>
      <schema:name>Dune (Imaginary place)</schema:name>
      <schemap:sameThingAs
  rdf:resource="http://id.loc.gov/authorities/subjects/sh92003142"/>
    </rdf:Description>
```

```
    <rdf:Description rdf:about="http://id.worldcat.org/fast/899474">
      <madsrdf:isIdentifiedByAuthority
  rdf:resource="http://id.loc.gov/authorities/subjects/sh92003142"/>
      <rdf:type rdf:resource="http://bibframe.proposed.org/TopicalConcept"/>
      <bf:label>Dune (Imaginary place)</bf:label>
    </rdf:Description>
  </rdf:RDF>
```

Figure 3.3. Descriptions of a controlled subject heading

Nevertheless, Figure 3.3 masks a fundamental difference between the OCLC and BIBFRAME approaches to authoritative descriptions. In the OCLC model, the primary concepts are people, places, organizations, things, and concepts; authority files, such as VIAF or the Library of Congress Subject Headings, are creative works that are sources of information about them. But in BIBFRAME, the primary concept is the explicitly defined Authority class, which may focus on descriptions of persons, organizations, places, things, and concepts.

The difference may appear trivial, but it has important implications. For example, the OCLC model can describe people or things not represented in the BIBFRAME Authority class (by removing the rdf:about statement and replacing it with a blank node), but it is not clear how this is done in BIBFRAME. And the OCLC model can relate references to the same person in different authorities by giving special preference to aggregators such as VIAF or by asserting 'sameAs' properties, such as the draft Schema Bib Extend property schemap:sameThingA. But in the BIBFRAME descriptions we have seen, properties such as hasVIAFlink and hasDeweylink are simply listed in the same description, about which an equivalence must be inferred. Finally, the OCLC model can refer to new authorities as they become available by citing appropriate URIs in the 'about' and 'sameAs' statements; but in the BIBFRAME design, a new property must be defined whenever a new authority when it is promoted to a citable status. Since references to authorities in the OCLC and BIBFRAME models have the potential to diverge significantly, this issue is being addressed in a separate position paper.

- The BIBFRAME representation of Items is less detailed.

  The draft OCLC model has a pathway from FRBR Manifestations (equivalent to schema:ProductModel) to a subset of non-specified exemplars (described as schema:SomeProducts) to FRBR Items (equivalent to schema:IndividualProduct). We envision that many detailed descriptions can be attached to these sub-classes. These descriptions range from classic elements of bibliographic description, such as publication date and edition, which are typically represented as properties of FRBR Manifestations; to models of acquisition, circulation, and holdings, which would usually be associated with exemplars but may refer to FRBR Items if they are uniquely identifiable. But it is not clear how these distinctions would be made in the BIBFRAME model, since bf:Instance conflates FRBR Manifestation and Item. Perhaps a combination of bf:Instance, bf:Annotation, and some tightly constrained best-practices guidelines will induce these distinctions, but it remains to be seen whether the results will be machine-processable.

4. Toward an alignment between the BIBFRAME and OCLC Schema models

The relationship between the OCLC model derived from Schema.org and BIBFRAME is, in our view, much clearer than it was just two months ago—in large part because of innovations in Schema.org, a recognition that these changes could be exploited to describe important library concepts, and an acknowledgment that concepts analogous to BIBFRAME Work and Instance must be associated to the OCLC model in a more transparent fashion. But the respective roles of Schema.org and BIBFRAME in the description of library resources remain the same. They were represented at the Library of Congress-sponsored BIBFRAME meeting at the ALA meeting in January 2013 and are reproduced in Figure 4.1 with some simplification. The coverage of Schema.org is necessarily broad but shallow because library resources must compete with creative works offered by many other communities in the information landscape. And the coverage of BIBFRAME is narrow but deep because it is the next-generation standard of record for describing library collections. A few concepts are identical, or at least have a relationship that can be translated into a robust mapping algorithm.

The biggest change since the earlier OCLC report is the relationship of the recently drafted 'Bib Extensions' vocabulary to Schema.org as well as to BIBFRAME. From the Schema.org perspective, the extensions now represent a much smaller set of classes and properties, and they are being proposed as candidates to be fully absorbed into the search engine standard, not loosely attached in a separate namespace. From the BIBFRAME perspective, the extensions represent a retreat from OCLC's initial goal of presenting a competing vocabulary for the description of content, carrier, holding, and other concepts unique to the library community. As a result, the three-way mapping among Schema.org, OCLC's 'library' extensions vocabulary, and BIBFRAME implied in the earlier version of Figure 4.1 has been eliminated. The relationships are now essentially complementary.

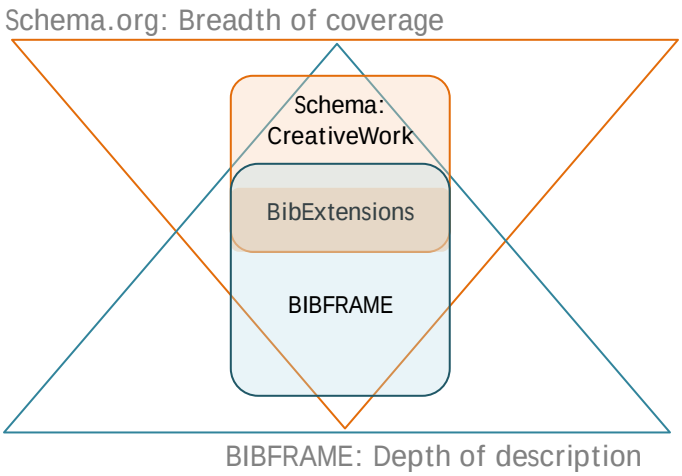

Figure 4.1. High-level alignment of BIBFRAME and Schema Bib Extend vocabularies

But this new alignment raises an important question. If the relationship between the Schema Bib Extend and BIBFRAME vocabulary is nearly disjoint, shouldn't the model developers who use this vocabulary also play complementary roles as they continue to work? We certainly can't afford duplicated effort because there is too much work to do. To address this issue, it is possible to define a set of complementary tasks that range from abstract to concrete, conducted at first by a small number of modeling experts and expanding to full involvement by the interested public. This is not a project plan or a charter, but an attempt to understand how the two models can be developed cooperatively and in tandem.

Model. The analysis described in this document demonstrates an obvious conclusion: neither the OCLC Schema nor the BIBFRAME model has an adequate representation of the FRBR Group I concepts, despite their fundamental importance in the description of library resources. Other important concepts are collections, series, and holdings. Users of both models need these concepts, and independent efforts are already underway to define and make them operational. But there is an urgent need for advocates of the two models to cooperate because the models will be difficult to align if the outcomes are radically different.

Looking beyond the common need to define a small number of concepts, however, the two models have different goals, which define different modeling priorities. The goal of models based on Schema.org is the discovery of bibliographic resources in general-purpose search engines, amid the clutter of offerings from publishers, e-content aggregators, booksellers, and others who provide access to similar materials. This goal requires strategies that value economy of description, such as using Schema.org whenever possible, and proposing revisions where necessary, but minimizing them. Yet once a library resource is discovered, the power

of BIBFRAME can be enlisted to drill down into descriptions that place library resources into the richest context that librarianship can support. This goal requires strategies that value curatorial interest, attention to detail, and continuous innovation.

One consequence of the different priorities is already visible in the two models. The OCLC Schema model has a fill-in-the-obvious-gaps quality that was especially evident in the previous version, but is still present. But BIBFRAME is potentially self-contained, free-standing, and in some places redundant with Schema.org. This is a reasonable alignment. If the BIBFRAME model is designed to minimize its dependence on Schema.org, the library community is not adversely affected if Schema.org changes radically or falls into disuse. Modeling effort would still be required to align BIBFRAME's most important concepts with any new generic ontology endorsed by the major search engines, but the more specialized concepts should, hopefully, remain unaffected.

Engage. BIBFRAME and models based on Schema.org both require community engagement to move forward.

The W3C Schema Bib Extend Community Group is currently advancing three goals. First, they are proposing a small number of properties such as schemap:hasInstance and schemap:commonEndeavor, with the goal of incorporating them into the schema: namespace through engagement with the Schema.org design team. Second, schema:CreativeWork and schema:Product are being examined for redundancies that resulted when the GoodRelations ontology was incorporated into Schema.org; these need to be removed. Finally, the Schema Bib Extend W3C community group is evaluating the suitability of the GoodRelations ontology for representing some of the FRBR Group I concepts as well as common library transactions such as acquisitions, circulation, and holdings. These are big tasks. And they are fundamentally different from the community engagement being conducted by the leaders of the BIBFRAME community to merge, map, or harmonize BIBFRAME with important library standards such as MARC, RDA, and MADS. But the results should be mutually beneficial. Models based on Schema.org would benefit from the more detailed descriptions of library resources that would emerge from the BIBFRAME effort. And the BIBFRAME advocates would benefit from the Schema Bib Extend effort to increase the visibility of library resources in generic search engines.

Map. One of the benefits of side-by-side comparisons like the one described in this document is that the aligned concepts in OCLC's Schema model and BIBFRAME reveal themselves. Among them are Person, Author, Director, Organization, Place, ISBN, hasInstance, isInstanceOf, Genre, Hardcover, Audiobook, Book, Label and Name, Movie and Motion Picture, and Subject and About – nearly all of the classes and properties required to describe the examples discussed in this position paper. As the two models mature, users of models derived from

Schema.org will produce a formal map to BIBFRAME concepts, expressed as a set of OWL statements, and make it public. As of this writing, many of the important concepts are equivalent; and those that are not can be expressed in simple set-theoretic terms. For example, bf:Instance is a superset of the Manifestation proxy defined in the OCLC model by the co-occurrence of schema:CreativeWork + schemaProductModel, as described in Section 2.1.

The BIBFRAME community must also define mappings and make them public. Many mappings from MARC have already been defined. This activity is arguably much more difficult than the task of aligning BIBFRAME to models based on Schema.org. The relationships between MARC and BIBFRAME may be many-to-many and not easily expressible in set-theoretic terms or in any algorithmically recoverable format. As a result, the mappings will be lossy and the outcomes will have to be vetted with cataloging communities whose work has been affected. Though OCLC's linked data researchers have also defined mappings from MARC, they are nearing the end of what can be accomplished without deeper engagement with the library community. This is a natural role for the BIBFRAME initiative.

Our hope is that the slightly overlapping but mostly complementary vocabularies that result from BIBFRAME and models based on Schema.org will be, at a practical level, enabling for libraries, their suppliers, and system developers who work in both kinds of organizations. In simple terms, the publication of data about library resources should not require the maintenance of competing data models. Data consumers should be able to flip a switch to a model designed for broad web and search engine engagement; or to BIBFRAME, designed for rich library interaction. Or they could request a combination of both, which would give the richest representation of all.

Appendix

The Schema.org and BIBFRAME instance data discussed in this article is reproduced in full below. The Turtle syntax was hand-coded and submitted to the RDFLib Translator (powered by RDFLib 3.2.2) to produce the RDF/XML syntax.

Example 1: The OCLC Schema model

Turtle syntax

```
@prefix schema: <http://schema.org/>.
@prefix schemap: <http://proposed-schema.org/>.
@prefix pto: <http://www.productontology.org/id/>.
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@prefix madsrdf: <http://www.loc.gov/standards/mads/rdf/>.
@prefix bf: <http://bibframe.org/vocab/>.
@prefix herbert: <http://herbert.example/>.
@prefix frbr: <http://vocab.org/frbr/core/>.

# Bundle 1: a FRBR Work (Movie)
herbert:1
a schema:Movie;
        schema:name "Dune";
        schema:director <http://viaf.org/viaf/164455045>;
        schema:about <http://id.worldcat.org/fast/899474>;
        schemap:hasInstance herbert:3;
        schemap:CommonEndeavor herbert:2;
.

# Bundle 2: a FRBR Work (Book)
herbert:2
        a schema:Book;
        schema:name "Dune";
        schema:genre "Fiction";
        schema:author <http://viaf.org/viaf/5908379>;
        schema:about <http://id.worldcat.org/fast/899474>;
        schemap:hasInstance herbert:4;
        schemap:commonEndeavor herbert:1;
```

```
.

# Bundle 3: a FRBR Expression (Movie)
herbert:3
        a schema:Movie;
        schema:name "Dune";
        schema:copyrightYear "2001";
        schemap:isInstanceOf herbert:1;
        schemap:hasInstance herbert:5;
.

# Bundle 4: a FRBR Expression (Book).
# Shows experimental use of frbr:Expression discussed in the text.
herbert:4
        a schema:Book, frbr:Expression;
        schema:name "Dune";
        schema:copyrightYear "1965";
        schemap:isInstanceOf herbert:2;
        schemap:hasInstance herbert:6;
.

# Bundle 5: a FRBR Manifestation (Movie)
herbert:5
        a schema:Book, schema:ProductModel, pto:DVD;
        schema:productID "upc:012236126297";
        schema:datePublished "2001";
        schemap:isInstanceOf herbert:3;
.

# Bundle 6: a FRBR Manifestation (Book)
herbert:6
        a schema:Book, schema:ProductModel, pto:Hardcover;
        schema:isbn "0801950775";
        schema:datePublished "1965";
        schemap:isInstanceOf herbert:4;
        #schemap:hasInstance herbert:7;
.

# Bundle 7: a FRBR Item (Book)
#Shows some hypothetical Holdings data.
herbert:7
        a schema:Book, schema:IndividualProduct, pto:Hardcover;
        schema:productID "barcode:71176";
        schemap:isInstanceOf herbert:6;
        schema:inventoryLevel [ a schema:QuantitativeValue; schema:hasValue "1"];
        schema:itemCondition schema:DamagedCondition;
```

```
.

# a person
<http://viaf.org/viaf/5908379>
a schema:Person;
        schema:name "Herbert, Frank";
        madsrdf:isIdentifiedbyAuthority <http://id.loc.gov/authorities/names/n80044450>;
.

# a person
<http://viaf.org/viaf/164455045>
        a schema:Person;
        schema:name "Lynch, David";
.

# a subject
<http://id.worldcat.org/fast/899474>
a bf:TopicalConcept;
        schema:name "Dune (Imaginary place)";
        schemap:sameThingAs <http://id.loc.gov/authorities/subjects/sh92003142>;
.
```

RDF/XML syntax

```
<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF
   xmlns:madsrdf="http://www.loc.gov/standards/mads/rdf/"
   xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
   xmlns:schema="http://schema.org/"
   xmlns:schemap="http://proposed-schema.org/"
>

  <rdf:Description rdf:nodeID="ub19bL72C23">
    <rdf:type rdf:resource="http://schema.org/QuantitativeValue"/>
    <schema:hasValue>1</schema:hasValue>
  </rdf:Description>

  <rdf:Description rdf:about="http://herbert.example/5">
    <schema:productID>upc:012236126297</schema:productID>
    <schemap:isInstanceOf rdf:resource="http://herbert.example/3"/>
    <rdf:type rdf:resource="http://www.productontology.org/id/DVD"/>
    <rdf:type rdf:resource="http://schema.org/ProductModel"/>
    <rdf:type rdf:resource="http://schema.org/Book"/>
    <schema:datePublished>2001</schema:datePublished>
  </rdf:Description>

  <rdf:Description rdf:about="http://viaf.org/viaf/164455045">
    <rdf:type rdf:resource="http://schema.org/Person"/>
```

```
    <schema:name>Lynch, David</schema:name>
  </rdf:Description>

  <rdf:Description rdf:about="http://herbert.example/6">
    <schema:isbn>0801950775</schema:isbn>
    <schemap:isInstanceOf rdf:resource="http://herbert.example/4"/>
    <rdf:type rdf:resource="http://www.productontology.org/id/Hardcover"/>
    <rdf:type rdf:resource="http://schema.org/ProductModel"/>
    <rdf:type rdf:resource="http://schema.org/Book"/>
    <schema:datePublished>1965</schema:datePublished>
  </rdf:Description>

  <rdf:Description rdf:about="http://viaf.org/viaf/5908379">
    <rdf:type rdf:resource="http://schema.org/Person"/>
    <schema:name>Herbert, Frank</schema:name>
    <madsrdf:isIdentifiedbyAuthority
rdf:resource="http://id.loc.gov/authorities/names/n80044450"/>
  </rdf:Description>

  <rdf:Description rdf:about="http://herbert.example/2">
    <schema:about rdf:resource="http://id.worldcat.org/fast/899474"/>
    <schema:author rdf:resource="http://viaf.org/viaf/5908379"/>
    <rdf:type rdf:resource="http://schema.org/Book"/>
    <schema:name>Dune</schema:name>
    <schemap:hasInstance rdf:resource="http://herbert.example/4"/>
    <schema:genre>Fiction</schema:genre>
    <schemap:commonEndeavor rdf:resource="http://herbert.example/1"/>
  </rdf:Description>

  <rdf:Description rdf:about="http://herbert.example/7">
    <schema:productID>barcode:71176</schema:productID>
    <schemap:isInstanceOf rdf:resource="http://herbert.example/6"/>
    <schema:itemCondition rdf:resource="http://schema.org/DamagedCondition"/>
    <rdf:type rdf:resource="http://schema.org/IndividualProduct"/>
    <rdf:type rdf:resource="http://www.productontology.org/id/Hardcover"/>
    <rdf:type rdf:resource="http://schema.org/Book"/>
    <schema:inventoryLevel rdf:nodeID="ub19bL72C23"/>
  </rdf:Description>

  <rdf:Description rdf:about="http://herbert.example/4">
    <schema:copyrightYear>1965</schema:copyrightYear>
    <schemap:isInstanceOf rdf:resource="http://herbert.example/2"/>
    <schemap:hasInstance rdf:resource="http://herbert.example/6"/>
    <rdf:type rdf:resource="http://vocab.org/frbr/core/Expression"/>
    <rdf:type rdf:resource="http://schema.org/Book"/>
    <schema:name>Dune</schema:name>
  </rdf:Description>

  <rdf:Description rdf:about="http://id.worldcat.org/fast/899474">
    <rdf:type rdf:resource="http://bibframe.org/vocab/TopicalConcept"/>
    <schema:name>Dune (Imaginary place)</schema:name>
    <schemap:sameThingAs
rdf:resource="http://id.loc.gov/authorities/subjects/sh92003142"/>
  </rdf:Description>
```

```
  <rdf:Description rdf:about="http://herbert.example/1">
    <rdf:type rdf:resource="http://schema.org/Movie"/>
    <schema:about rdf:resource="http://id.worldcat.org/fast/899474"/>
    <schema:name>Dune</schema:name>
    <schemap:CommonEndeavor rdf:resource="http://herbert.example/2"/>
    <schema:director rdf:resource="http://viaf.org/viaf/164455045"/>
    <schemap:hasInstance rdf:resource="http://herbert.example/3"/>
  </rdf:Description>

  <rdf:Description rdf:about="http://herbert.example/3">
    <schema:copyrightYear>2001</schema:copyrightYear>
    <schemap:isInstanceOf rdf:resource="http://herbert.example/1"/>
    <schemap:hasInstance rdf:resource="http://herbert.example/5"/>
    <rdf:type rdf:resource="http://schema.org/Movie"/>
    <schema:name>Dune</schema:name>
  </rdf:Description>
</rdf:RDF>
```

Example 2: BIBFRAME

Turtle syntax

```
@prefix bf: <http://bibframe.org/vocab/> .
@prefix bfp: <http://bibframe.proposed.org/> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@prefix madsrdf: <http://www.loc.gov/standards/mads/rdf/>.
@prefix herbert: <http://herbert.example/>.

# Bundle 1: a BIBFRAME Work (Movie)
herbert:1
a bfp:MotionPicture;
        bf:label "Dune";
        bf:director <http://viaf.org/viaf/164455045>;
        bfp:copyrightDate "2001";
        bf:hasInstance herbert:3;
.

# Bundle 2: a BIBFRAME Work (Book)
herbert:2
a bfp:Book;
        bf:label "Dune";
        bf:genre "Fiction";
        bf:author <http://viaf.org/viaf/59083797>;
        bf:subject <http://id.worldcat.org/fast/899474>;
        bfp:copyrightDate "1965";
        bf:hasInstance herbert:4;
.

# Bundle 3: a BIBFRAME Instance (Movie)
herbert:3
```

```
    a bfp:DVD;
            bfp:upc "01223612697";
            bf:isInstanceOf herbert:1;
    .
    # Bundle 4: a BIBFRAME Instance (Book)
    herbert:4
    a bfp:Hardcover;
            bf:isbn "0801950775";
            bfp:barcode "71176";
            bf:date "1965";
            bf:isInstanceOf herbert:2;
    .
    # a person
    <http://viaf.org/viaf/59083797>
    a bf:Person;
            madsrdf:isIdentifiedbyAuthority <http://id.loc.gov/authorities/names/n80044450>;
            bf:label "Herbert, Frank";
    .
    # a person
    <http://viaf.org/viaf/164455045>
    a bf:Person;
            bf:label "Lynch, David";
    .
    # a subject
    <http://id.worldcat.org/fast/899474>
    a bfp:TopicalConcept;
            madsrdf:isIdentifiedByAuthority <http://id.loc.gov/authorities/subjects/sh92003142>;
            bf:label "Dune (Imaginary place)";
    .
```

RDF/XML Syntax

```
<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF
   xmlns:bf="http://bibframe.org/vocab/"
   xmlns:bfp="http://bibframe.proposed.org/"
   xmlns:madsrdf="http://www.loc.gov/standards/mads/rdf/"
   xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
>

  <rdf:Description rdf:about="http://viaf.org/viaf/59083797">
    <bf:label>Herbert, Frank</bf:label>
    <madsrdf:isIdentifiedbyAuthority
rdf:resource="http://id.loc.gov/authorities/names/n80044450"/>
    <rdf:type rdf:resource="http://bibframe.org/vocab/Person"/>
  </rdf:Description>

  <rdf:Description rdf:about="http://herbert.example/4">
    <bf:isbn>0801950775</bf:isbn>
    <bf:isInstanceOf rdf:resource="http://herbert.example/2"/>
    <bf:date>1965</bf:date>
    <bfp:barcode>1965</bf:barcode>
    <rdf:type rdf:resource="http://bibframe.proposed.org/Hardcover"/>
```

```
  </rdf:Description>

  <rdf:Description rdf:about="http://herbert.example/1">
    <bf:hasInstance rdf:resource="http://herbert.example/3"/>
    <bf:label>Dune</bf:label>
    <rdf:type rdf:resource="http://bibframe.proposed.org/MotionPicture"/>
    <bfp:copyrightDate>2001</bfp:copyrightDate>
    <bf:director rdf:resource="http://viaf.org/viaf/164455045"/>
  </rdf:Description>

  <rdf:Description rdf:about="http://herbert.example/3">
    <bf:isInstanceOf rdf:resource="http://herbert.example/1"/>
    <rdf:type rdf:resource="http://bibframe.proposed.org/DVD"/>
    <bfp:upc>01223612697</bfp:upc>
  </rdf:Description>

  <rdf:Description rdf:about="http://viaf.org/viaf/164455045">
    <bf:label>Lynch, David</bf:label>
    <rdf:type rdf:resource="http://bibframe.org/vocab/Person"/>
  </rdf:Description>

  <rdf:Description rdf:about="http://herbert.example/2">
    <rdf:type rdf:resource="http://bibframe.proposed.org/Book"/>
    <bf:hasInstance rdf:resource="http://herbert.example/4"/>
    <bfp:copyrightDate>1965</bfp:copyrightDate>
    <bf:genre>Fiction</bf:genre>
    <bf:author rdf:resource="http://viaf.org/viaf/59083797"/>
    <bf:subject rdf:resource="http://id.worldcat.org/fast/899474"/>
    <bf:label>Dune</bf:label>
  </rdf:Description>

  <rdf:Description rdf:about="http://id.worldcat.org/fast/899474">
    <madsrdf:isIdentifiedByAuthority
rdf:resource="http://id.loc.gov/authorities/subjects/sh92003142"/>
    <rdf:type rdf:resource="http://bibframe.proposed.org/TopicalConcept"/>
    <bf:label>Dune (Imaginary place)</bf:label>
  </rdf:Description>
</rdf:RDF>
```