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Positioning Library Data for the Semantic Web: Recent Developments in Resource Description

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Abstract

Recent developments in resource description standards and technologies have aimed at moving cataloging practice to the web environment and making library data available for exchange and reuse on the Semantic Web. As the library community looks outward and forward, library standards and technologies are converging with Web practices in three areas: content description, data models, and data exchange. This article captures the essence of the core standards and technologies that underlie the daily work of practitioners of library service, including Resource Description and Access (RDA), Functional Requirements for Bibliographic Records (FRBR), the Linked Data environment, Resource Description Framework (RDF), and the Bibliographic Framework Transition Initiative (BIBFRAME). The article will discuss their intersections with existing practice during this period of transition, as well as their potential impacts on the future cataloging practice.

Keywords

Keywords: Cataloging, Linked Data, Resource Description and Access, Resource Description Framework, Bibliographic Initiative Framework, Semantic Web, Entity-Relationship Models

Figure Captions

Figure 1. RDF triples as mathematical expressions.

Figure 2. RDF triples expressed in XML.

Figure 3. RDF triples shown as tables.

Figure 4. RDF triples shown as labeled, directed graphs. Rounded shapes represent entity references; diamonds represent relationships; rectangles represent entity literals.

Figure 5. A single graph combining all the triples in Figure 4.

Figure 6. The graph in Figure 5, but showing URIs instead of lexical labels.

Figure 7. The future "catalog record" (in gray), according to the BIBFRAME structure, will include content description as well as a number of annotations gathered from around the Web.

Positioning Library Data for the Semantic Web: Recent Developments in Resource Description

by Kimmy Szeto

We are poised to witness a revolutionary moment for library technology. In the past half-century, the electronic library catalog evolved on a parallel path with publicly accessible networks, such as the World Wide Web. The OPAC and discovery systems have served as distinct points of contact, but library data continue to reside largely in isolated library silos. Recent developments in several library technical standards will bring about a grand technological convergence with the Web in three areas: (1) content description, (2) data models, and (3) data exchange.

These new standards will change the way resources are described, as well as how library data will be structured, accessed, and used by the library community and beyond. There is a wealth of technical literature on these technical topics. (A list of further reading is provided at the end of this article.) In this article, I aim to capture the essence of these technologies that underlie the daily work of practitioners of library service, and to discuss the potential impacts on cataloging practice these developments might bring. I will clarify some potentially confusing terminologies, and illustrate some concepts graphically. I will also explain how some of these technologies will intersect and overlap during this period of transition.

An Overview of Recent Advances in Resource Description Standards and Technologies

Already upon us is the new content description standard Resource Description and Access (RDA), which will replace the Anglo-American Cataloging Rules, 2nd edition (AACR2). RDA is modeled on the Functional Requirements for Bibliographic Records (FRBR), which so far has existed as a concept with vast potential to revolutionize resource description, but has encountered difficulties reconciling with AACR2 concepts, rules, and terminologies. RDA represents a revision to AACR2 that implements FRBR concepts and incorporates FRBR terminology. The convergence of RDA and FRBR will focus cataloging, or resource description, on the resources' relationships with each other, and steer the process of retrieval and access towards navigating links through a hierarchy of relationships. This change in emphasis positions libraries to participate in the emerging Semantic Web.

The Semantic Web aims to generalize the World Wide Web, which mostly consists of hyperlinked documents, to a web of data, where web resources are systematically linked so that machine processing can yield meaningful knowledge and inferences about the data for human consumption. The set of underlying principles that allow this systematic structure to exist is Linked Data. The concept is not new—it has been widely applied in areas such as controlled heading in library catalogs (since the 19th century!), database models, filing systems, and through the network of scholarly citation practices. RDA converges with Linked Data principles by complying with the Resource Description Framework (RDF), the data model required for Linked Data. In a parallel effort to the development of textual guidelines and instructions, RDA is also designed as a set of RDF classes and properties, as well as associated vocabularies.

Expressing library data in a manner compliant with Semantic Web standards will foster information exchange and reuse in the broader web of data outside the library world.

The data model supported by RDA will also provide the basis for migrating legacy library data currently isolated in MARC-based systems. The Library of Congress launched the Bibliographic Framework Transition Initiative (BIBFRAME) to develop the successor to the current Machine-Readable Cataloging exchange format (MARC 21). Complementing RDA, BIBFRAME will represent the third area of convergence. BIBFRAME will allow bibliographic data to be encoded as linkable data, a vehicle for accessibility on the Semantic Web.

Convergences in Resource Description Technologies and Standards

Convergence 1: Modeling RDA on FRBR

FRBR

Functional Requirements for Bibliographic Records (FRBR) is a conceptual model developed by the International Federation of Library Associations and Institutions (IFLA). The IFLA Study Group described a generalized conceptual model that establishes entities and relationships for information objects (IFLA 1997). Until then, terms such as “book,” “edition,” “publication,” “work,” and “item” were not always precise. When we refer to “this book,” are we referring to this particular object (a FRBR Item), or all the identical printed copies of this particular publication (a FRBR Manifestation)? Or are we more referring more broadly to the collective conceptual contents in the book (a FRBR Work)? Or are we referring to this work in the text form, in a specific language (a FRBR Expression)? These are clearly delineated in a hierarchy in FRBR’s Group 1 entities.

FRBR’s Group 2 entities consist of Person and Corporate Body. Group 2 and Group 1 entities are linked through specific relationships, much like relating a title to an author, to an illustrator, to an editor, etc. An important attribute of each Group 2 entity is the Role. Role provides the relator term that often goes unrecorded in bibliographic records. It is a crucial piece of information that supplies meanings to relationships in the Semantic Web environment.

FRBR’s Group 3 entities supply Concept, Object, Event, and Place information to any Group 1 or Group 2 entity, much like applying subject headings to a title or authority data about a person.

In addition to establishing these inherent relationships, FRBR also delineates content relationships. We encounter content relationships in reprints, photocopies, and microform (equivalent relationship), in translations, revisions, and arrangements (derivative relationship), in parodies and adaptations to a different genre (a new Work related to the original), in reviews, criticisms, and annotations (descriptive relationship to the original), as well as between issues and serials (whole/part relationship), and for issues of serials, books with CD-ROMs, and music score and parts (sequential, accompanying, and companion relationship). Catalogers often encounter these relationships and make cataloging decisions that ultimately affect users’ catalog search results. For example, will a user find Shakespeare’s *Romeo and Juliet* in a search for Bernstein’s *West Side Story*?

For graphical illustrations of FRBR’s three groups of entities and bibliographic relationships, refer to Barbara Tillett (2004).

FRBR relates the bibliographic model with user processes through four User Tasks—Find, Identify, Select, and Obtain. These user tasks reiterates the Charles Cutter’s objectives of a library catalog (Cutter 1875) as users navigate through all the interrelated FRBR entities, and completes FRBR’s holistic approach to the bibliographic universe.

RDA Based on FRBR

The FRBR model has great influence on the development of RDA. In fact, in the early stages of revising AACR2, one of the principles of what was then AACR3 was to incorporate FRBR terminology and concepts (Joint Steering Committee for the Development of RDA [JSC], 2005 January 12), and to align the organization of RDA with the FRBR model (JSC, 2005 May 19; JSC, 2009). However, without a viable data model, RDA would remain a content standard for producing textual statements. A web-ready, web-scale data model is necessary for the next convergence.

Convergence 2: RDA in RDF: Library Data as Linked Data

RDA in RDF

Another significant corollary of RDA's convergence with FRBR is moving resource description from flat sequences of statements to the application of the hierarchical, entity-relationship model. Not only does the model facilitate user tasks, it also aligns library cataloging practice to the general model of relational database design, as well as the data model underlying the Semantic Web. To facilitate this, the developers of RDA formalized RDA's element set based the the Resource Description Framework data model. RDF, developed by the World Wide Web Consortium (W3C), is compliant with a host of Semantic Web technologies such as OWL (Web Ontology Language), RDFS (RDF Schema Language) , and SKOS (Simple Knowledge Organization System) vocabularies. This extensibility is central to RDA's aim of opening library data to the wider Semantic Web.

RDF works well with FRBR in that they both subscribe to the entity-relationship model when drawing relationships between resources. Additionally, it provides a data structure for meaning to be embedded, and for knowledge to be built on these embedded meanings. RDF's formalism is quite complex (Klyne and Carroll 2004), but the concept is surprisingly straightforward. RDF relationships are expressed in statements that take this form:

THING → is in a RELATIONSHIP with → a different THING

This RDF statement, also known as the RDF triple, has three parts: two "things" and one unidirectional relationship in between (all three parts carry equal weight). This concept is widely used in fields like mathematics, linguistics, and database design, so the nomenclature varies for the RDF triple. Here are some common terms that are roughly equivalent:

Database:	Entity → Relationship → Entity
Sentence:	Subject → Predicate → Object
Directed Graph:	Node → Arc/Edge → Node
Cataloging:	Resource → has Property → Value

In Web implementations, the most commonly used method to express these relationships is Extensible Markup Language (XML). But there are other ways to visualize RDF. It can be shown using mathematical expressions, in tabular form, or, as a labeled, directed graph. Since RDF is conceptual, visualizations cannot always fully represent the concepts, and can pose limitations legibility. XML and mathematical expression are difficult for the human eye to read; the tabular form is limited to showing relationships in two dimensions. The labeled, directed graph offers the most flexibility for the purpose of illustration.

[PLACE FIGURE 1, 2, 3, 4 HERE]

Linked Data Implementation

Linked Data

To implement the RDF model on the Web and link all these entities and relationships together over the Web, we will need to add a few standards and ways of identifying and addressing these objects. This is where Linked Data Principles come in.

The idea of linking one set of information to another through an identifier, a number, or a keyword is well established. Programmers and developers use pointers in programming languages and draw relationships in relational databases. In everyday use, whether in the electronic or analog environment, arranging and filing documents and records invariably includes elements of linking data. In business, the customer number on an invoice links to the customer's account; manufacturer numbers link to product descriptions and inventory. In libraries, we link bibliographic records to holding and item records, and we link names and subjects to authority files.

On the World Wide Web, the concept of linking has most often applied to hyperlinking between documents (i.e., linking between discrete files containing text or binary data using a URL). This use of hyperlinking shows that a relationship exists between two documents, but does not specify the nature of the relationship. In the generalized Linked Data environment, relationships carry meaning (or semantics), and objects are not limited to documents, but can refer to any data, any "thing"—entities like concept, place, event, and person, and relationships themselves are objects as well. The resulting Web will then be more "meaningful," or semantically rich. But of course, content providers and users of this Semantic Web will need to follow a set of common principles for the design, structure, and presentation of data, otherwise the data will simply be ignored. Tim Berners-Lee was first to articulate the four Linked Data principles as a set of best practices for the Semantic Web (Berners-Lee 2006):

1. Use URIs as names for things.

The unique identifier is a familiar cataloging concept. It is also fundamental to Semantic Web technology, where every resource must be named with a globally unique Universal Resource Identifier (URI) in order to distinguish it from any other resource.

2. Use HTTP URIs so that people can look up those names.

These URIs are required to be in a specific form according to the HyperText Transfer Protocol (HTTP). URLs, widely used on the Web for locating documents, is one type of HTTP URI.

3. When someone looks up a URI, provide useful information, using the standards (RDF, SPARQL).

Berners-Lee (2006) recommends HTTP URIs so that the identifier can also serve as the Web locator that allows users to retrieve the definition and other related information about a resource, a feature known as dereferencing. Standards such as Resource Description Framework (RDF) and the SPARQL Protocol and RDF Query Language (SPARQL) allow semantics to be embedded in the data. RDA, in particular, works with RDF.

4. Include links to other URIs so that they can discover more things.

When a critical mass of online data sets follows these principles, the Linked Data environment will enable large-scale integration and reasoning over globally connected data sets on the Semantic Web.

Expressing RDF as Linked Data

When Linked Data principles are applied to the RDF model, each of the three parts of an RDF triple must have a HTTP URI. But this is not always possible in implementation. Therefore, the formulation of RDF entities allows for three forms: reference (using URI), literal (text), and blank (placeholder). The “blank” accounts for the situation where an entity is created but no name is assigned, for example, as an intermediate step in a metadata creation workflow, or when a resource is a collection of further links but itself contains no useful information. Some information needs to be exact text, such as transcribed statements, and this text is represented as literals. Some literals such as date, LCCN, ISBN, etc. can be consistently formatted for machine processing.

As for URIs, while optimal for machine processing, these long strings of text are not useful for human use. For convenience of human manipulation, URIs may have a lexical labels. These lexical labels are, in fact, what we have been using for authorized forms. But unlike URIs, labels are not inherently unique. On the other hand, URIs are required to be unique. Therefore, in the Linked Data environment, URIs replace lexical labels as authorities.

Expressing RDA in RDF

Figures 3 and 4 illustrate an example of how to interpret information in table form and re-imagine it as a labeled, directed graph. In Figure 3, the table contains a list of information about various books. Before we look at specific data entries, consider that this entire table represents a group of similar entities. These similar entities are grouped together into Classes, and there is an entity class we now call Works. Within the table, each column header represents one particular property, for example, the Author column in Figure 3 is represented as the "has Author" property in Figure 4. These authors can be grouped together as the entity class Person. As we fill in actual data for each of the rows, the resulting triples are called Instances of the triple.

Linking Library Data

To further illustrate Linked Data principles at work, examine Figure 4. Notice there are several entities that are repeated. These entities, which are identical, can be combined to form a single, larger graph (Figure 5). As more information becomes available, entities that are identified as identical or equivalent can be merged in the same way into the graph, and additional links to other resources will be added to the graph. As a result, the graph will expand, and can expand infinitely.

In this environment, bibliographic description is no longer based on the bibliographic record as a unit. The unbounded nature and the ability to merge are the key features of the Linked Data environment that make it possible for the library catalog to interface with data outside the library community and become a part of the global Web of knowledge. Different data sources that use equivalent concepts and relationships can be seamlessly integrated by direct human intervention, or by computer programs; resources and concepts that are not exactly identical can be mapped algorithmically using reasoning engines.

Cataloging as Linked Data

To implement a cataloging practice that reflects RDF triples as in Figure 5, all the resources and properties need to have a unique URI. But what are these URIs? What are the definition and scope of these resources? What exactly is a Work? What exactly is a Person? Where are these terms dereferenced? More broadly, can existing cataloging standards be carried over into this new data model?

Figure 6 shows the underlying URIs referencing RDA properties and Library of Congress authorities. RDA's RDF properties and entity classes are formally defined and published in the Open Metadata Registry (RDA, 2013; Hillman 2010), and Library of Congress authorities and vocabularies are published by the Linked Data Service (http://id.loc.gov). These registered entities define how these properties are to be used, and how they are related to each other internally and to external entities, such as authority data, controlled vocabularies, thesauruses, or code lists. The metadata registries will guide catalogers in their formation of graphs, as well as provide the necessary URIs, and ultimately make RDA properties available for other communities to use for such purposes as real time validation, synchronization, and application development (Bizer, Heath, and Berners-Lee 2009). This puts the library community in a position to enter the broader Semantic Web.

[PLACE FIGURE 5 and 6 HERE]

Convergence 3: Library Data Exchange Format for the Semantic Web

MARC for Linked Data?

Most elements of the MARC format have been analyzed and mapped to RDF properties (Coyle 2011; Hillmann and Dunsire 2012). However, because MARC was developed over four decades ago to automate the creation and printing of catalog cards, the format presents many structural limitations in adapting to the web-based environment (McCallum 2012). RDA, unlike AACR, is not limited to standardizing description for the purpose of printed catalog cards. Emphasizing recording bibliographic data over composing textual records, RDA is a general-purpose content standard with the flexibility to lend itself to any form of data presentation and transmission. So, while RDA is fully supported in MARC 21, it is possible to pair it with other exchange formats. This flexibility encourages the library community to re-imagine a bibliographic environment that fuses seamlessly with the Linked Data environment.

BIBFRAME

BIBFRAME, the next data exchange format to replace MARC, is still in development at the conceptual level. Like RDA, it will be developed as an independent model. BIBFRAME will definitely work with RDA, but can also work with other content standards like DACS (Describing Archives: A Content Standard) and CCO (Cataloging Cultural Objects). BIBFRAME will continue to support bibliographic description, authority data, holdings, and classification, and will be able to address all types of holdings, including digital and born-digital materials. In the meantime, BIBFRAME will take advantage of the groundwork that has been made on the content standards and linked data fronts, such as making use of URIs whenever applicable.

Data in BIBFRAME fall into four core classes: Work, Instance, Authority, and Annotation. (To set BIBFRAME concepts apart from FRBR concepts, the prefixes BF and FRBR will be used.) According to a preliminary report (LC 2012), BF Work encompasses “the conceptual essence of the cataloged item”; BF Instance reflects “an individual, material embodiment of the [BF] Work.” Note that BIBFRAME’s Work-Instance structure is slightly different from that of FRBR: BF Work encompasses both FRBR Work and FRBR Expression, whereas BF Instances are very similar to FRBR Manifestation. BF Authority associates “key authority concepts that have defined relationships reflected in the [BF] Work and [BF] Instance.” Examples include topics, people, institutions, and places. BF Annotation is a resource that “decorates other BIBFRAME resources with additional information. This is a new concept for additional assertions, such as reviews, abstract, and excerpts (relating to BF Work); holdings, book cover images, and tables of contents (relating to BF Instance); and authority information and administrative metadata (relating to BF Annotation) to be actively sought out for library data. (For graphical illustrations of BIBFRAME’s entities, refer to the preliminary report (LC 2012).)

The notable difference of BF Annotations from the other core classes is that it is not designed to be controlled, but is either created locally or drawn from the Web. The notion of BF Annotation will decentralize data, augmenting bibliographic data with selected external sources, as well as local resources and user-generated tags or comments. Current cataloging practice already allows a limited amount of external data (for example, external links in the MARC 856 field). But including external data as a central component has the potential to redefine the scope and goals of cataloging. Figure 7 shows the composition of a future "catalog record" that will be searched and displayed. In addition to providing resource description according to content description rules, a number of annotations will be gathered from around the web.

[PLACE FIGURE 7 HERE]

Iterative development of the BIBFRAME model is ongoing; testing of mappings and conversion tools is in the preliminary stages. Even though BIBFRAME is designed to be format-neutral, its development will focus on ensuring compatibility with RDA and RDF.

The Future of Resource Description

These technological convergences all aim to expose library data to the wider web of data for exchange and reuse, as well as to enrich library data with resources from the Semantic Web. What will the work of a cataloger be like in the future?

For now, catalogues will continue to use MARC, and to type lexical labels in textual descriptions. As RDA adoption becomes more widespread, we will begin to adapt to a new way of conceiving of resource description. RDA has laid the groundwork; authority data and vocabularies are ready to be employed.

Resource description of the future will be done on the Web, for the Web. We will no longer be concerned with whether the entry will print, nor will we select the main entry over added entries. With the expanded availability of authorities, we will spend more time looking for suitable vocabularies and linking to them. The shift of emphasis on recording the URI over lexical labels might mean less typing but more drag-and-drop and prune-and-graft, should vendors develop the graphical interface. Catalogers' role will be more akin to that of data curators. They will establish search policies for external resources from the entire Web, configure systems to harvest these external data, and set the scope of the local display.

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Figure 1

```
{Work, titleOfTheWork, Hamlet}
{Work, Author, Person}
{Person, nameOfThePerson, "Shakespeare, William, 1564-1616"}
```

Figure 2


```xml
<?xml version="1.0" encoding="UTF-8"?>
<!--This fragment is created for illustration purposes only and is not intended to
demonstrate any encoding standard.-->
<rdaSimple
       xmlns:rda="http://rdvocab.info/Elements/"
       xmlns:rdg2="http://rdvocab.info/ElementsGr2/"
       xmlns:rdg3="http://rdvocab.info/ElementsGr3/"
       xmlns:frbr="http://rdvocab.info/uri/schema/FRBRentitiesRDA"
       xmlns:role="http://rdvocab.info/roles/"
       >
   <frbr:Work uri="http://rdvocab.info/uri/schema/FRBRentitiesRDA/Work">
      <rda:titleOfTheWork>
          Hamlet
       </rda:titleOfTheWork uri="http://rdvocab.info/Elements/titleOfTheWork">
       <role:author uri="http://rdvocab.info/roles/authorWork">
         <frbr:Person uri="http://rdvocab.info/uri/schema/FRBRentitiesRDA/Person">
           <rdg2:nameOfThePerson uri="http://rdvocab.info/ElementsGr2/nameOfThePerson">
             <frbr:Name uri="http://rdvocab.info/uri/schema/FRBRentitiesRDA/Name"
             id="http://id.loc.gov/authorities/names/n78095332" vocab="LCNAF">
               Shakespeare, William, 1564-1616
             </frbr:Name>
           </rdg2:nameOfThePerson>
         </frbr:Person>
       </role:author>
   <frbr:Work>
</rdaSimple>
```

Figure 3

Title	Author
Hamlet	William Shakespeare
Hamlet	Peter Ilich Tchaikovsky

Name	Date of Birth	Authoritative Label
William Shakespeare	1564	Shakespeare, William, 1564-1616
Peter Ilich Tchaikovsky	1840	Tchaikovsky, Peter Ilich, 1840-1893

Figure 4

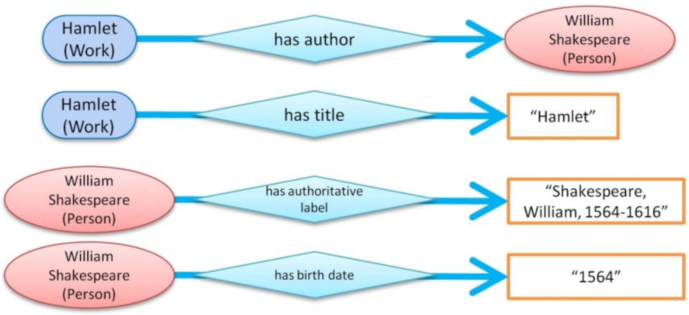

Hamlet (Work)
has author
William Shakespeare (Person)
Hamlet (Work)
has title
"Hamlet"
William Shakespeare (Person)
has authoritative label
"Shakespeare, William, 1564-1616"
William Shakespeare (Person)
has birth date
"1564"

Figure 5

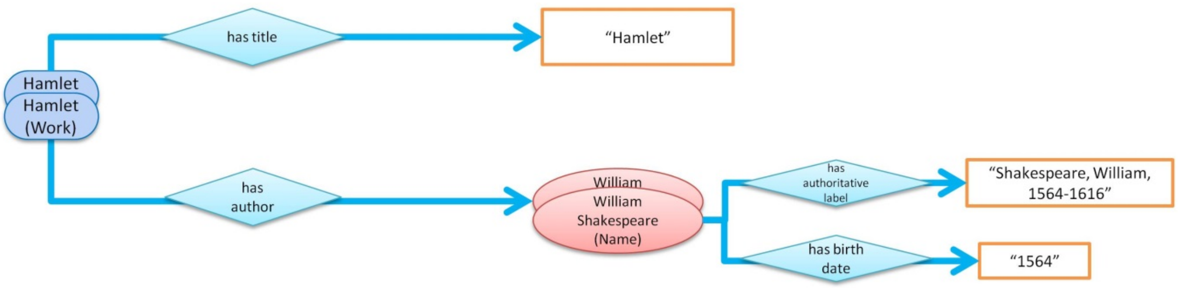
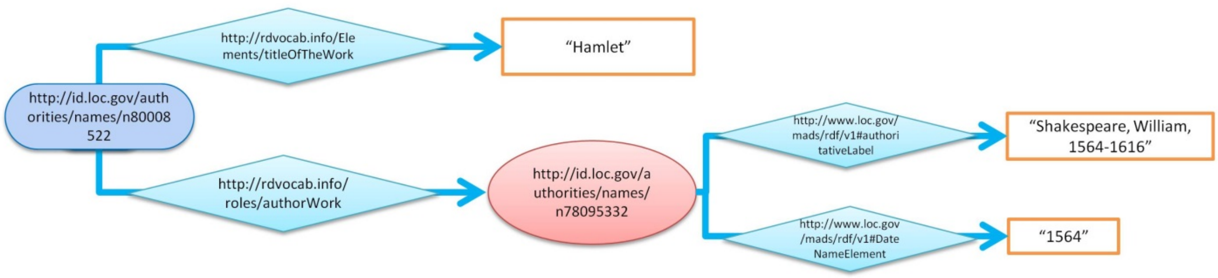

has title
"Hamlet"
Hamlet
Hamlet
(Work)
has
author
William
William
Shakespeare
(Name)
has
authoritative
label
"Shakespeare, William,
1564-1616"
has birth
date
"1564"

Figure 6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http://rdvocab.info/Elements/titleOfTheWork
"Hamlet"
http://rdvocab.info/roles/authorWork
http://id.loc.gov/authorities/names/n78095332
http://www.loc.gov/mads/rdf/v1#authoritativeLabel
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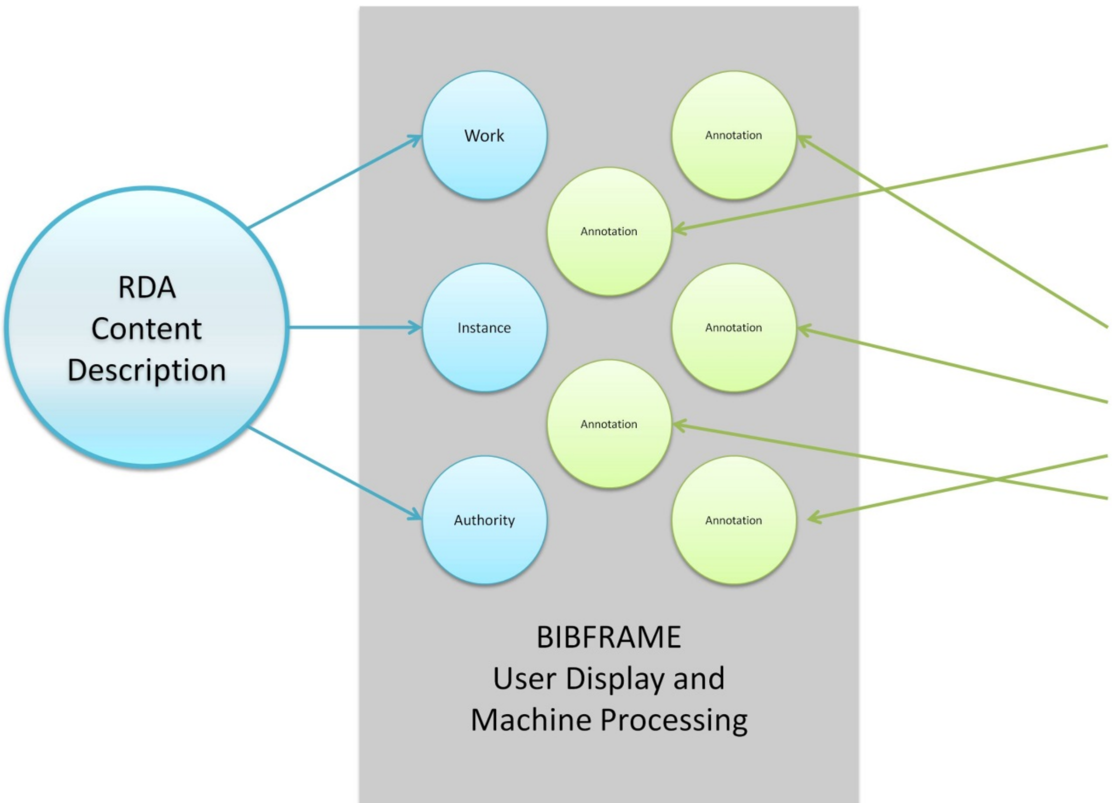
"1564"

Figure 7


RDA
Content
Description
Work
Instance
Authority
Annotation
Annotation
Annotation
Annotation
Annotation
Annotation
BIBFRAME
User Display and
Machine Processing