

Encoding FRBR Information in the Handle System

The LSAL FRBR semantic model, applied to the Handle System

Introduction and Terms

We investigated how a “semantic model” could be used to represent our work involving FRBR and the Handle System in order to see if, and how, such a model could be used in the future to describe CORDRA as a whole.

A semantic model describes a specific domain’s information, relationships, and rules. This is expressed with an ontology – a term with its foundation in philosophy. The term is oft-misused and construed as a variety of things, but in this paper it should be interpreted as a representation of hierarchical data including properties of- and relationships between entities.

Interestingly, the Semantic Web is highly reliant on a standardized ontology language in order to express the meaning contained in information, across domains.

Protégé Editor

Our semantic model for the Functional Requirements for Bibliographic Records (FRBR) entities we experimented with was created with Stanford University’s Protégé¹ tool. Protégé is a “free, open source ontology editor and knowledge-base framework”, which means that it can be used to both create ontologies, as well as input ontologically categorized information to create knowledge bases. We used only the ontological functionality.

Protégé uses *classes* to represent objects; these classes have *slots*, which are fields of a certain type (string, number, instance of another class, etc.) and have cardinality information (required, multiple allowed, etc.). Classes can be nested to create a hierarchical structure, where slots of a parent class are inherited by child classes, but can be overridden if necessary. Figure 1 shows an example of this in the default Protégé interface. Note the hierarchical class structure in the left pane, beginning with the root “cordra”, and the slots in the right pane, beginning with “cordra_record_id”.

¹ <http://protoge.stanford.edu>

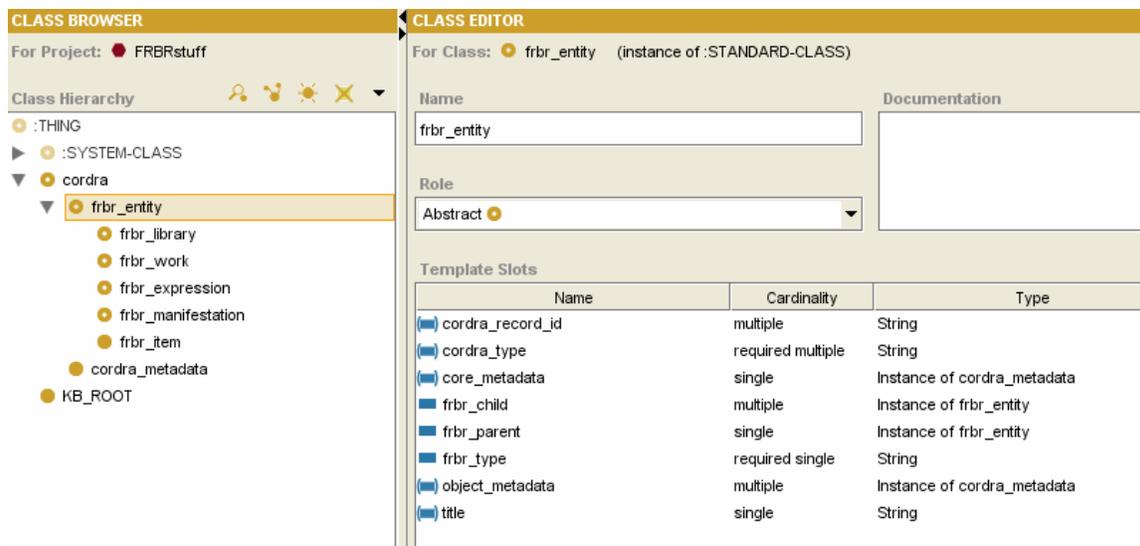


Figure 1

LSAL FRBR Semantic Model

See Appendix A for the full semantic model.

See LSAL QuickTip: Using FRBR to Classify Digital Content

(<http://hdl.handle.net/1870/BFC8F0E2717E4B99AB94BD95EED0C9EF>) for an introduction to FRBR.

We needed to model how specific FRBR information (such as entity type, and relationships between types) would be represented in a given storage system. We wanted a generic representation allowing for different types of storage – this generic representation is the semantic model.

In addition to the basic FRBR entities Work, Expression, Manifestation and Item, we added a FRBR Library entity as a way to maintain collections of FRBR Works. This was a logical extension of the existing FRBR model.

A root *cordra* Protégé class was created to encapsulate all objects we intended to encode. This provided global slots that every CORDRA object would have, such as a title or references to other metadata.

Classes were also created for objects we needed to represent: FRBR entities (*frbr_library*, *frbr_work*, *frbr_expression*, *frbr_manifestation*, *frbr_item*) and metadata (*cordra_metadata*). Again, we exploited the Protégé's class inheritance feature by creating a *frbr_entity* parent class to contain the five FRBR classes, which allowed ease in managing the shared slots for these FRBR classes.

Various Metadata

We wanted to allow for various kinds of metadata to be attached to instances of our semantic model classes.

The first and most basic kind of metadata we required was a simple title or name for each entity, in order to assist human interaction with the instances of our semantic model classes.

Additionally, we needed a way to link an instance of a semantic model class with its core and object metadata. Core metadata is that which is or should be maintained for every instance of a cordra class. Object metadata is “additional” metadata, and may be based upon the type of cordra class (a FRBR entity, for example).

Class Hierarchy

Figure 2 shows the entire class hierarchy within Protégé for our semantic model. Recall that slots on a parent class are inherited by child classes.

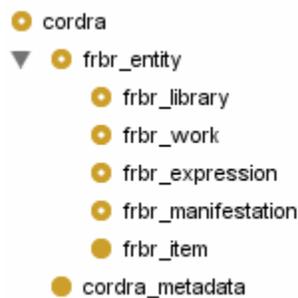


Figure 2

Classes & Class-local Slots

Listed below are class slots unique to that class. Note some details of slots, such as inherited and overridden slots, as well as cardinality, are not detailed here; see Appendix A for full details.

Some slots seem redundant and are marked with an asterisk (*), but are required for certain storage systems such as the Handle System.

cordra

The *cordra* class is used to encapsulate all other classes. No object is instantiated as type *cordra*. Currently, there are two subclasses of the *cordra* class, *frbr_entity* and *cordra_metadata*; there may others in the future.

Local Slot Name	Slot Description
cordra_type*	The class type of this CORDRA object, either <i>frbr_entity</i> or <i>cordra_metadata</i> .
title	Title or name of this object.
core_metadata	Reference to core metadata about this object.
object_metadata	Reference to object metadata about this object.
cordra_record_id	Information about registries this object has been registered in.

frbr_entity

The *frbr_entity* class is used to encapsulate all of our FRBR classes. No object is instantiated as simply a *frbr_entity* – all *frbr_entity* objects include additional information regarding their actual type (Library, Work, etc.).

Local Slot Name	Slot Description
<i>frbr_type</i> *	The class type of this FRBR entity, either <i>frbr_library</i> , <i>frbr_work</i> , <i>frbr_expression</i> , <i>frbr_manifestation</i> , or <i>frbr_entity</i> .
<i>frbr_child</i> *	The children of this FRBR entity in the FRBR hierarchy.
<i>frbr_parent</i> *	The parent of this FRBR entity in the FRBR hierarchy.

frbr_library

The *frbr_library* class represents an instance of a FRBR Library object.

No additional slots.

A *frbr_library* may not have any *frbr_parent* entries, and *frbr_child* entries must be of the type *frbr_work*.

frbr_work

The *frbr_work* class represents an instance of a FRBR Work object.

No additional slots.

A *frbr_work* may not have any *frbr_parent* entries, and *frbr_child* entries must be of the type *frbr_expression*.

frbr_expression

The *frbr_expression* class represents an instance of a FRBR Expression object.

No additional slots.

A *frbr_expression* has *frbr_parent* entries of type *frbr_work*, and *frbr_child* entries of type *frbr_manifestation*.

frbr_manifestation

The *frbr_manifestation* class represents an instance of a FRBR Manifestation object.

Local Slot Name	Slot Description
<i>url</i>	The internet location of this manifestation.

A *frbr_manifestation* has *frbr_parent* entries of type *frbr_expression*, and *frbr_child* entries of type *frbr_item*.

frbr_item

The *frbr_item* class represents an instance of a FRBR Item object.

No additional slots.

A *frbr_item* has *frbr_parent* entries of type *frbr_manifestation*, and may not have *frbr_child* entries.

Note: We do NOT use the *frbr_item* class in our software, however it is included for consistency with the FRBR model.

cordra_metadata

The *cordra_metadata* class is used to represent instances of both core and object metadata.

No additional slots.

Semantic Model in the Handle System

Handle System Basics

The Handle System was chosen as our storage system for FRBR information. The Handle System is a set of protocols and software created by the Corporation for National Research Initiatives (CNRI), and allows for the creation of globally unique identifiers with any number of attributes – in essence, a simple database of triples.

In general, a triple is a statement (or sentence, or assertion) about something, in the form <Subject><Verb/Attribute><Object/Value>.

- <This Paper><authored by><Learning Systems Architecture Lab>
- <This Paper><original format><Microsoft Word 2000>
- <Handle System website><located at><<http://www.handle.net>>

Incidentally, triples form the base of the W3C's RDF specification and Berners-Lee's Semantic Web vision.

A Handle System identifier (“handle”) looks something like:
1870/08A75686FC2145F7896E8D31D13A2FAE

In general, a handle identifier is in the format,
<naming authority>/<local name>

where the “naming authority” is ensured unique by the global Handle System, and the “local name” is ensured unique by local handle server software.

Within a handle identifier, attributes can be created, which are a basic name/value pair:

1870/08A75686FC2145F7896E8D31D13A2FAE

Name	Value
URL	“http://www.cordra.net”
Title	“CORDRA homepage”

The Subject of the related triples is the handle identifier itself, so the corresponding triple statements for the above attributes are:

Subject	Verb/Attribute	Object/Value
1870/08A75686FC2145F7896E8D31D13A2FAE	URL	"http://www.cordra.net"
1870/08A75686FC2145F7896E8D31D13A2FAE	Title	"CORDRA homepage"

Our Solution

We created a method for encoding the FRBR semantic model's classes and slots into an identifier's attributes.

In our encoding, one handle represents an *instance* of a semantic model class, and its attributes and values are used to represent slot information. For example, **1870/F56A4938A23B4F66A4A931CC1032D4D4** is an instance of a FRBR Work (details on why in the table below).

One exception to this rule is a set of identifiers within the Handle System naming authority "1870.types"; these identifiers represent the actual semantic model classes.

Handle Attribute / Semantic Model Binding

See Appendix B for a detailed listing of Handle attributes, including applicability and value spaces.

Semantic Model Class

To represent which root-level semantic model class an identifier is an instance of, we created an attribute named **CORDRA_TYPE**. The value of CORDRA_TYPE is a handle within the "1870.types" Handle System naming authority.

CORDRA_TYPE Value	Semantic Model Class
hdl:1870.types/frbr_entity	<i>frbr_entity</i>
hdl:1870.types/cordra_metadata	<i>cordra_metadata</i>

We further distinguished instances of the *frbr_entity* semantic model class into their respective FRBR entity types with an attribute named **FRBR_TYPE**. The value of FRBR_TYPE is a handle within the "1870.types" Handle System naming authority.

FRBR_TYPE Value	Semantic Model Class
hdl:1870.types/frbr_library	<i>frbr_library</i>
hdl:1870.types/frbr_work	<i>frbr_work</i>
hdl:1870.types/frbr_expression	<i>frbr_expression</i>
hdl:1870.types/frbr_manifestation	<i>frbr_manifestation</i>
hdl:1870.types/frbr_item	<i>frbr_item</i>

FRBR Parent & Child Relationships

Now that we had a way to identify instances of FRBR Works, Expressions, etc., we needed a method for encoding the relationships between entities – such as the child Expressions for a Work.

Two attributes were created for these relationships – **FRBR_CHILD** and **FRBR_PARENT** – in order for us to encode both parent-child and child-parent (for efficiency) relationships. These attributes contain a handle representing the *frbr_entity* that is an identifier's parent or child (e.g., for a FRBR Work, **FRBR_CHILD** would contain a handle for a FRBR Expression of that Work). These attributes can appear multiple times to represent each child and parent of a given *frbr_entity*.

Metadata

We used an attribute named **TITLE** to represent an object's title or name.

We used two attributes, **CORE_METADATA** and **OBJECT_METADATA**, to link an object to its respective core or object metadata. The identifier contained in the value of these attributes must be a **CORDRA_METADATA** object.

Note that metadata related fields are global to all **CORDRA** objects.

Putting it all Together

Combining all of these handle attributes together allows us to represent semantic model class instances and relationships between those instances within the handle system. This could be encoded into handles by hand, using any standard tool that creates and edits handles.

We created a set of web services that allows for the creation of FRBR entities and metadata and enforces the relationships of the semantic model.

We also created the **FRBRLibraryViewer** that puts a user-friendly interface on top of the web services to allow a user to create and edit a FRBR tree. In addition, the **Simple CORDRA** manager was updated to use the Handle System as its database; the previous version used a SQL database to store all its information.

Example Handle Record

As mentioned earlier, the Handle identifier **1870/F56A4938A23B4F66A4A931CC1032D4D4** represents a FRBR Work entity. Here's why:

Detailed in Figure 3, the **CORDRA_TYPE** attribute contains the value "1870.types/frbr_entity". In other words, this identifier represents a FRBR entity.

If an identifier is a FRBR entity, then it must also contain the attribute **FRBR_TYPE**, and the value "1870.types/frbr_work" below indicates this is a FRBR Work.

This FRBR Work's title is "Handle System Overview Quick Tip", as indicated by the value of the **TITLE** attribute.

Finally, this Work has one child Expression, as indicated by the FRBR_CHILD attribute.

HANDLE SYSTEM →

Handle Values for: 1870/F56A4938A23B4F66A4A931CC1032D4D4		
Index	Type	Data
100	HS_ADMIN	Thu Nov 03 2005 11:28:13 EST handle=0.NA/1870; index=300; [create hdl,delete hdl,create NA,add val,read val,modify val,del admin,add admin,list]
1	CORDRA_TYPE	Thu Nov 03 2005 11:28:14 EST hdl:1870.types/frbr_entity
2	TITLE	Thu Nov 03 2005 11:28:15 EST metadata for Field Manual 34-130 @ LSAL Plone
3	FRBR_TYPE	Thu Nov 03 2005 11:28:16 EST hdl:1870.types/frbr_work
4	FRBR_CHILD	Thu Nov 03 2005 16:32:20 EST hdl:1870/72D674BCE34144608F13ABB6A33AA473

Figure 3

Exploiting the Handle System for Automated “Latest Version” Resolution

As described in (URL to Resolution system report), a resolution system can use FRBR information to select the most appropriate version of a resource, for example, based on the language of the resource, the technical format (Flash animation, PDF), or the physical location. The semantic model (and the associated web services) described in this paper support the data needed to create a resolution system.

One common use of the resolution system is to simply find the most recent version of a resource. We enabled this type of resolution using automated resolution of the latest *Manifestation* of the latest *Expression* of a *Work*. In other words, by providing a persistent link to a *Work*, we are able to automatically deliver the latest digital file to a user.

The Handle System web proxy allows users to write a URL that encodes a handle identifier, and the proxy software will automatically redirect the user to the value of the URL attribute stored in that handle (e.g., <http://hdl.handle.net/1870/1>).

For this resolution method to function, each *frbr_entity* with *frbr_child* entries must have the latest child’s web proxy URL entered as the parent’s handle URL attribute. In the example below, notice how a *Work* includes the web proxy URL to its child *Expression*, and the *Expression* contains the URL to its *Manifestation*.

- 1870/C953D00633FA416BAE0117BBCF9E31AB
 - CORDRA_TYPE hdl:1870.types/frbr_entity
 - FRBR_TYPE hdl:1870.types/frbr_work
 - URL <http://hdl.handle.net/1870/FAFFFBF809784CB3B7D927520B0DFFB2>
 - 1870/FAFFFBF809784CB3B7D927520B0DFFB2
 - CORDRA_TYPE hdl:1870.types/frbr_entity
 - FRBR_TYPE hdl:1870.types/frbr_expression
 - URL <http://hdl.handle.net/1870/5E2C5B9A02B74497891C2C5DF27E2560>

- 1870/5E2C5B9A02B74497891C2C5DF27E2560
CORDRA_TYPE hdl:1870.types/frbr_entity
FRBR_TYPE hdl:1870.types/frbr_manifestation
URL <http://www.cnn.com>

By providing the Work handle to an informed user, or the Work's web proxy URL (<http://hdl.handle.net/1870/C953D00633FA416BAE0117BBCF9E31AB>) in a web page or other document, the user can automatically retrieve the latest version.

NOTE: In our web services and related user interface (FRBRLibraryViewer), the "latest version" means the last manifestation added to the FRBR tree.

Appendix A – Detailed FRBR Semantic Model

For an HTML representation of this semantic model, see:

<http://hdl.handle.net/1870/983E16867E674B25957053382B57C7C2>.

For the Protégé source of this semantic model, see:

<http://hdl.handle.net/1870/155761C60A444CDFB44C96AAD2DE9499>.

FRBRstuff Class Hierarchy

- cordra
 - cordra_metadata
 - frbr_entity
 - frbr_expression
 - frbr_item
 - frbr_library
 - frbr_manifestation
 - frbr_work

Class: cordra

Superclasses

- :THING

Subclasses

- frbr_entity
- cordra_metadata

Template Slots					
	Slot Name	Documentation	Type	Cardinality	Min/Max
■	cordra_record_id		String	0:*	
■	cordra_type		String	1:*	
■	core_metadata		cordra_metadata	0:1	
■	object_metadata		cordra_metadata	0:*	
■	title		String	0:1	

Class: cordra_metadata

Superclasses

- cordra

Subclasses

- None

Template Slots					
	Slot Name	Documentation	Type	Cardinality	Min/Max
	cordra_record_id		String	0:*	
	cordra_type		String	1:*	
	core_metadata		cordra_metadata	0:1	
	object_metadata		cordra_metadata	0:*	
	title		String	0:1	

Class: frbr_entity

Superclasses

- cordra

Subclasses

- frbr_library
- frbr_work
- frbr_expression
- frbr_manifestation
- frbr_item

Template Slots					
	Slot Name	Documentation	Type	Cardinality	Min/Max
	cordra_record_id		String	0:*	
	cordra_type		String	1:*	
	core_metadata		cordra_metadata	0:1	
	frbr_child		frbr_entity	0:*	
	frbr_parent		frbr_entity	0:1	
	frbr_type		String	1:1	
	object_metadata		cordra_metadata	0:*	
	title		String	0:1	

Class: frbr_expression

Superclasses

- frbr_entity

Subclasses

- None

Template Slots					
	Slot Name	Documentation	Type	Cardinality	Min/Max
	cordra_record_id		String	0:*	
	cordra_type		String	1:*	
	core_metadata		cordra_metadata	0:1	
	frbr_child		frbr_manifestation	0:*	
	frbr_parent		frbr_work	1:1	
	frbr_type		String	1:1	
	object_metadata		cordra_metadata	0:*	
	title		String	0:1	

Class: frbr_item

Superclasses

- frbr_entity

Subclasses

- None

Template Slots					
	Slot Name	Documentation	Type	Cardinality	Min/Max
	cordra_record_id		String	0:*	
	cordra_type		String	1:*	
	core_metadata		cordra_metadata	0:1	
	frbr_child		frbr_entity	0:*	
	frbr_parent		frbr_manifestation	0:1	
	frbr_type		String	1:1	
	object_metadata		cordra_metadata	0:*	
	title		String	0:1	

Class: frbr_library

Superclasses

- frbr_entity

Subclasses

- None

Template Slots					
	Slot Name	Documentation	Type	Cardinality	Min/Max
	cordra_record_id		String	0:*	
	cordra_type		String	1:*	
	core_metadata		cordra_metadata	0:1	
	frbr_child		frbr_work	0:*	
	frbr_parent		frbr_entity	0:1	
	frbr_type		String	1:1	
	object_metadata		cordra_metadata	0:*	
	title		String	0:1	

Class: frbr_manifestation

Superclasses

- frbr_entity

Subclasses

- None

Template Slots					
	Slot Name	Documentation	Type	Cardinality	Min/Max
	cordra_record_id		String	0:*	
	cordra_type		String	1:*	
	core_metadata		cordra_metadata	0:1	
	frbr_child		frbr_item	0:*	
	frbr_parent		frbr_expression	1:1	
	frbr_type		String	1:1	
	object_metadata		cordra_metadata	0:*	
	title		String	0:1	
	url		String	0:*	

Class: frbr_work

Superclasses

- frbr_entity

Subclasses

- None

Template Slots					
	Slot Name	Documentation	Type	Cardinality	Min/Max
	cordra_record_id		String	0:*	
	cordra_type		String	1:*	
	core_metadata		cordra_metadata	0:1	
	frbr_child		frbr_expression	0:*	
	frbr_parent		frbr_entity	0:1	
	frbr_type		String	1:1	
	object_metadata		cordra_metadata	0:*	
	title		String	0:1	

Appendix B – Detailed Handle System Attributes

Handle Attribute Name	CORDRA_TYPE	
Description	Identifies which semantic model class this identifier is an instance of (cordra_metadata, frbr_work, etc.).	
Applicability	All CORDRA identifiers.	
Cardinality	Minimum: 1, Maximum: no maximum	
Attribute Value(s)	String Handle URI, restricted values listed below.	
	Value	Meaning
	hdl:1870.types/frbr_entity	The identifier is an instance of the semantic model <i>frbr_entity</i> class.
	hdl:1870.types/cordra_metadata	The identifier is an instance of the semantic model <i>cordra_metadata</i> class.

Handle Attribute Name	FRBR_TYPE	
Description	Identifies which semantic model subclass of <i>frbr_entity</i> this identifier is an instance of.	
Applicability	All identifiers of type <i>frbr_entity</i> .	
Cardinality	Minimum: 1, Maximum: 1	
Attribute Value(s)	String Handle URI, restricted values listed below.	
	Value	Meaning
	hdl:1870.types/frbr_library	The identifier is an instance of the semantic model <i>frbr_library</i> class.
	hdl:1870.types/frbr_work	The identifier is an instance of the semantic model <i>frbr_work</i> class.
	hdl:1870.types/frbr_expression	The identifier is an instance of the semantic model <i>frbr_expression</i> class.
	hdl:1870.types/frbr_manifestation	The identifier is an instance of the semantic model <i>frbr_manifestation</i> class.

	hdl:1870.types/frbr_item	The identifier is an instance of the semantic model <i>frbr_item</i> class.
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Handle Attribute Name	FRBR_CHILD
Description	Contains a reference to the child of a <i>frbr_entity</i> .
Applicability	Identifiers of <i>frbr_type</i> : <i>frbr_library</i> , <i>frbr_work</i> , <i>frbr_expression</i> , <i>frbr_manifestation</i> .
Cardinality	Minimum: 0, Maximum: no maximum
Attribute Value(s)	String Handle URI of the identifier representing this identifier's child. If this identifier is a <i>frbr_library</i> , the child identifier must be of type <i>frbr_work</i> . (etc.)

Handle Attribute Name	FRBR_PARENT
Description	Contains a reference to the parent of a <i>frbr_entity</i> .
Applicability	Identifiers of <i>frbr_type</i> : <i>frbr_expression</i> , <i>frbr_manifestation</i> , <i>frbr_item</i> .
Cardinality	Minimum: 0, Maximum: no maximum
Attribute Value(s)	String Handle URI of the identifier representing this identifier's parent. If this identifier is a <i>frbr_item</i> , the child identifier must be of type <i>frbr_manifestation</i> . (etc.)

Handle Attribute Name	TITLE
Description	Contains the name or title of this identifier.
Applicability	All CORDRA identifiers.
Cardinality	Minimum: 0, Maximum: 1
Attribute Value(s)	String.

Handle Attribute Name	CORE_METADATA
Description	Contains a reference to the core metadata for this identifier.
Applicability	All CORDRA identifiers.
Cardinality	Minimum: 0, Maximum: 1
Attribute Value(s)	String Handle URI of the identifier representing this identifier's core metadata (which must be of type <i>cordra_metadata</i>).

Handle Attribute Name	OBJECT_METADATA
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Description	Contains a reference to the object metadata for this identifier.
Applicability	All CORDRA identifiers.
Cardinality	Minimum: 0, Maximum: no maximum
Attribute Value(s)	String Handle URI of the identifier representing this identifier's object metadata (which must be of type <i>cordra_metadata</i>).